SYD

Windshear, Turbulence and Low Level Windshear Alerting System (LLWAS)

Sydney Airport (SYD)

Information booklet

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Foreword

We are pleased to partner with the International Federation of Air Line Pilots' Associations (IFALPA) and The Honourable Company of Air Pilots to prepare this booklet.

This booklet aims at providing pilots and air navigators with the basic information on windshear and turbulence, their causes, and the windshear and turbulence alerting service in Sydney.

The LIDAR (Light Detection and Ranging), first applied in aviation weather alerting by Hong Kong Observatory, is now accepted worldwide as the standard solution for detecting clear-air windshear and turbulence.

This booklet is provided for reference and education only and is in no way intended to replace individual airline company's Standard Operating Procedures.

XYZ

Post Holder, Sydney Airport

Xxx 2024

Keep reporting windshear and turbulence

Pilot reports (PIREPs) remain a key component of the windshear and turbulence warning service. Moreover, SYD Airport is continuously refining the Low-Level Windshear Alerting System (LLWAS) to enhance its accuracy using PIREPS as an established method to verify the alerts. Your support is indispensable to the windshear alerting service. If you encounter windshear, please **report the event to ATC**.

If you don't encounter it and it is being forecast and/or alerted, SYD Airport still needs to know, so tell ATC and SYD. Your reports will continue to be used to enhance the system. Thanks to all of you for the feedback!

Introduction

This booklet is in the form of questions and answers. It starts by explaining what windshear and turbulence are and then explains how the Low-Level Windshear Alerting System (LLWAS) at Sydney Airport (SYD) works.

Note: Whilst wind shear warnings (YSSY WS WRNG), turbulence forecasts (MOD or SEV TURB on YSSY TAF) and warnings for turbulence (via SIGMET for SEV TURB) will be issued by the Bureau of Meteorology (The Bureau). The booklet, however, explains what causes windshear and turbulence in and around SYD Airport and points out some important points that pilots should understand.

Most of you reading this booklet are experienced aviators and are already familiar with windshear and turbulence and how they are caused. You may, therefore, wish to treat it as a refresher. For others, this should elucidate what windshear and turbulence are and how they can affect an aircraft.

A Windshear / Microburst Alert is **not** an Air Traffic Control instruction but is advice to pilots. It is the responsibility of the pilot to determine what action to take upon receipt of such a message.

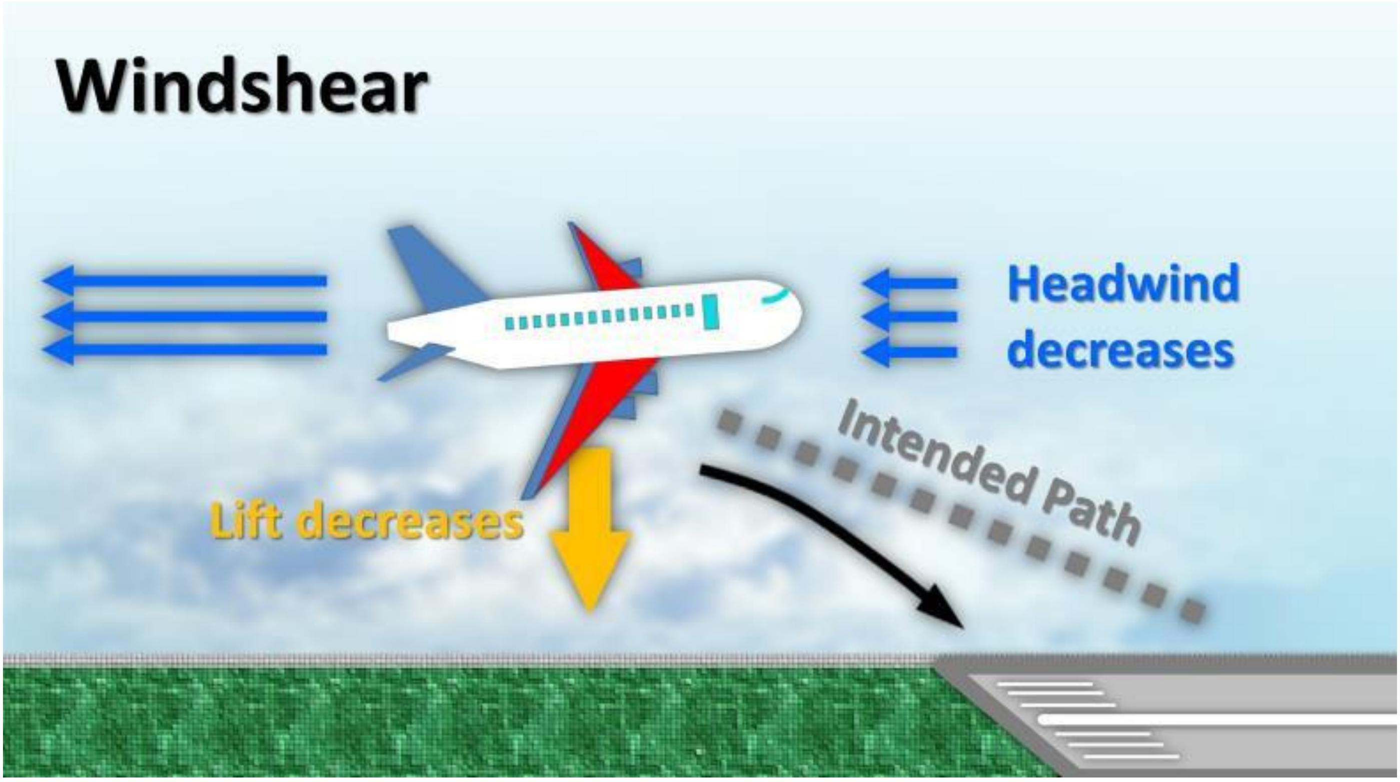
By the end of this booklet, you should understand, among others, the following:

1. How windshear alerts are generated.
2. The local phraseology, e.g. what the terms “Microburst Alert (MBA)” and “Windshear Alert (WSA)” mean in Sydney.
3. The reason why some aircraft encounters windshear while others do not.
4. If windshear alerts are issued, what you might experience.

Windshear

Windshear refers to a sustained change (i.e. lasting more than a few seconds as experienced by the aircraft) in the wind direction and/or speed, resulting in a change in the headwind or tailwind (i.e. the runway-oriented wind component) encountered by an aircraft. Decreased lift will cause the aircraft to go below the intended flight path (see figure below). Conversely an increased lift will cause the aircraft to fly above the intended flight path.

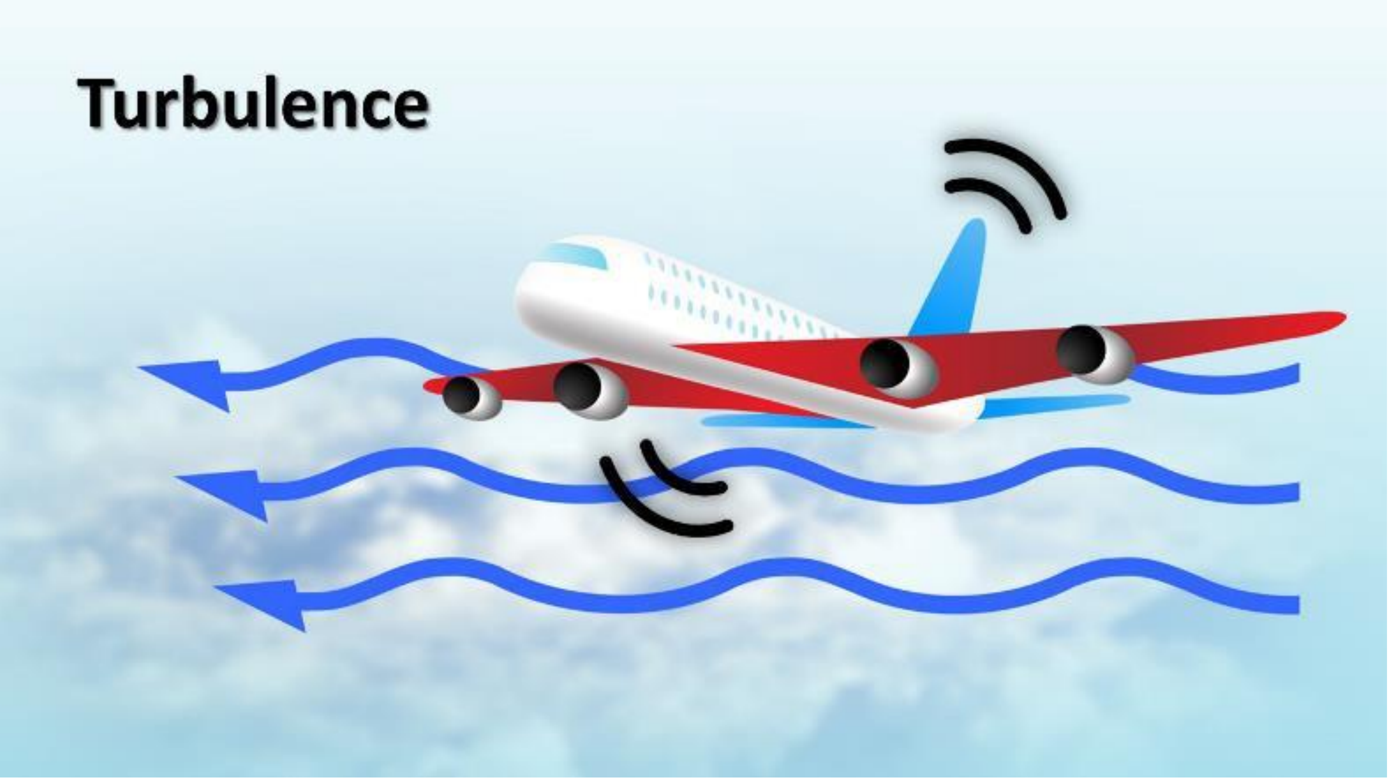
Pilots should be aware that significant windshear at low levels on approach and departure zones may cause difficulty in control, thus requiring timely and appropriate corrective actions to ensure aircraft safety.



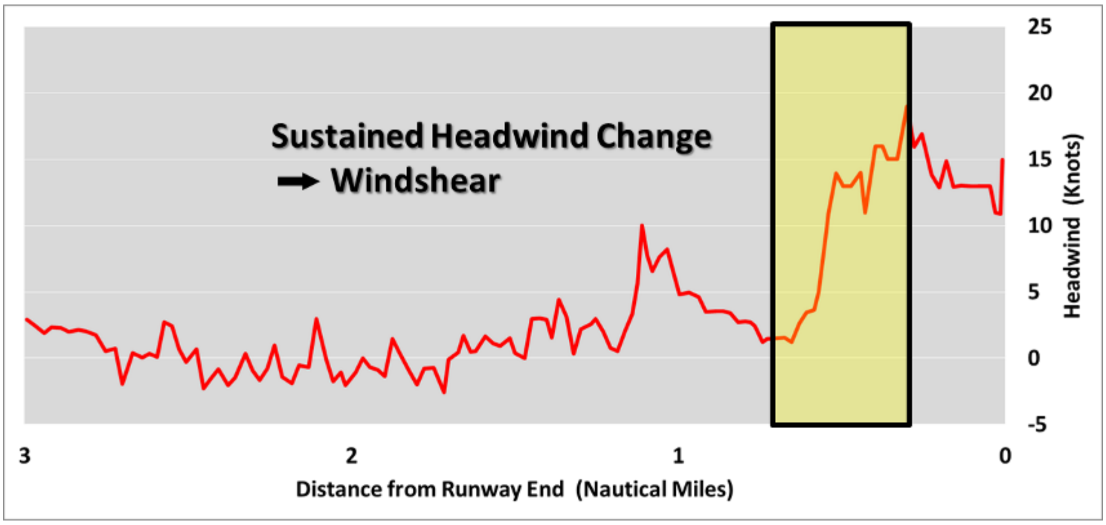
Turbulence

Turbulence is caused by rapid irregular motion of air. It brings about rapid bumps or jolts but does not normally influence the intended flight path of an aircraft significantly. However, in severe turbulence cases, abrupt changes in the altitude and attitude of the aircraft may occur and the pilot may suffer a momentary loss of control.

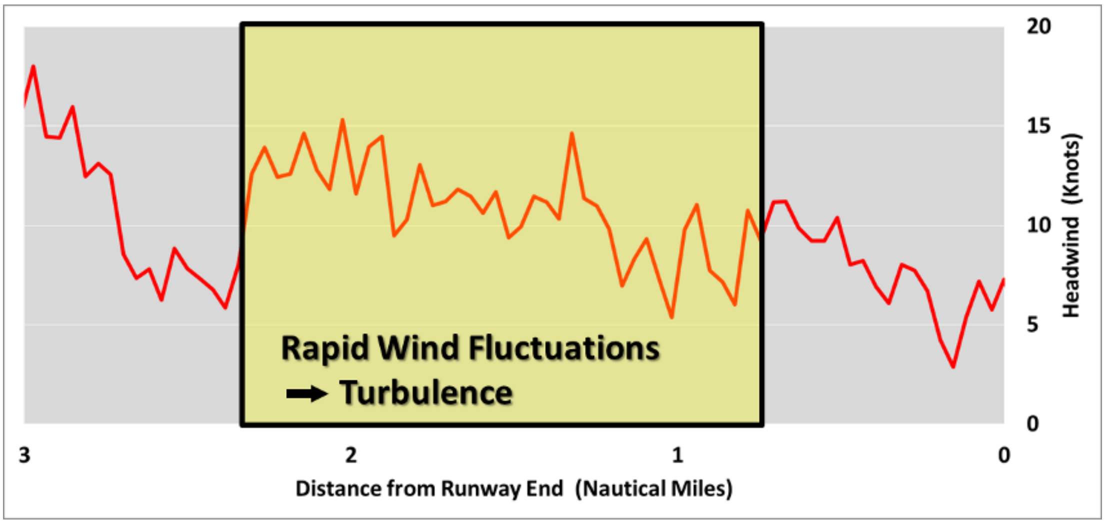
In general, rapid fluctuations in the wind speed and direction encountered by the aircraft are perceived as turbulence, whereas a sustained change of the headwind or tailwind of 15 knots or more for more than a few seconds is significant windshear.



The figure below shows the headwind profile retrieved from the flight data recorder (FDR) on an aircraft approaching Hong Kong International Airport (HKIA) under a sea breeze condition. The shaded area represents the location of the sea breeze front where the aircraft experienced significant windshear of headwind increase.



The next figure shows the headwind profile retrieved from the FDR on an aircraft approaching HKIA under a disturbed strong southwesterly wind condition. The shaded area represents the region where the aircraft experienced significant turbulence. The pilot reported moderate to severe turbulence along the glide path in this case.



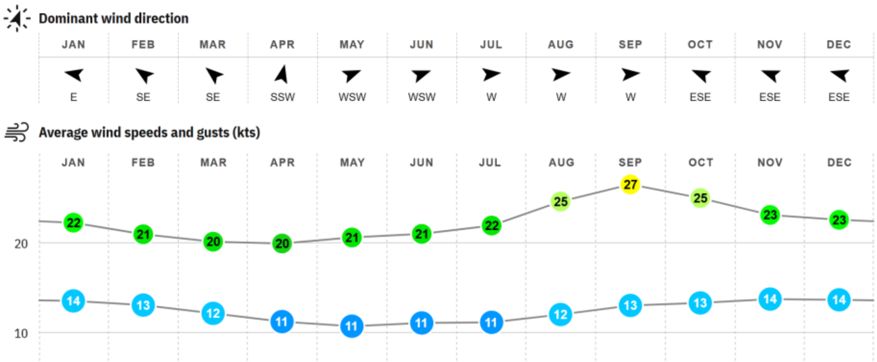
Windshear events can be very small scale, sporadic and transient in nature and may affect successive aircraft differently. Therefore, windshear or turbulence as experienced by an aircraft may at times differ from the conditions reported by the preceding aircraft and from the alerts provided.

Similar encounters can be expected at Sydney, though the wind directions and locations may vary.

Prevailing Winds at SYD

Based on the Bureau of Meteorology measurements recorded at Kingsford Smith Airport from 1995-2016, Sydney Airport is affected by prevailing winds from three directions, namely north-east, south and west. The southerly winds are by far the most frequent wind (September to April) for the Sydney region. Westerly winds occur most frequently from April to September. North-easterly winds occur most frequently during the late spring and the summer months (October to March) of the year.

Monthly wind speed statistics and directions for Sydney International Airport



With Thanks to WindFinder.

MET Conditions at Sydney

General MET Weather – Wet and Dry

Sydney has a temperate climate with warm summers and cool winters, with rainfall spread throughout the year. In addition, Sydney is a coastal city with associated ocean-effect convection conditions; the Sydney Airport runways project into Botany Bay, which opens to the Pacific Ocean.

Sydney International Airport is subject to a range of climatic conditions, including wind shear, microburst, gust front and thunderstorm activity, and during the summer months, the 'Southerly Buster'. Sydney experiences wind-shear events in both wet and dry conditions.

Southerly Wind Streams and Gale Fronts

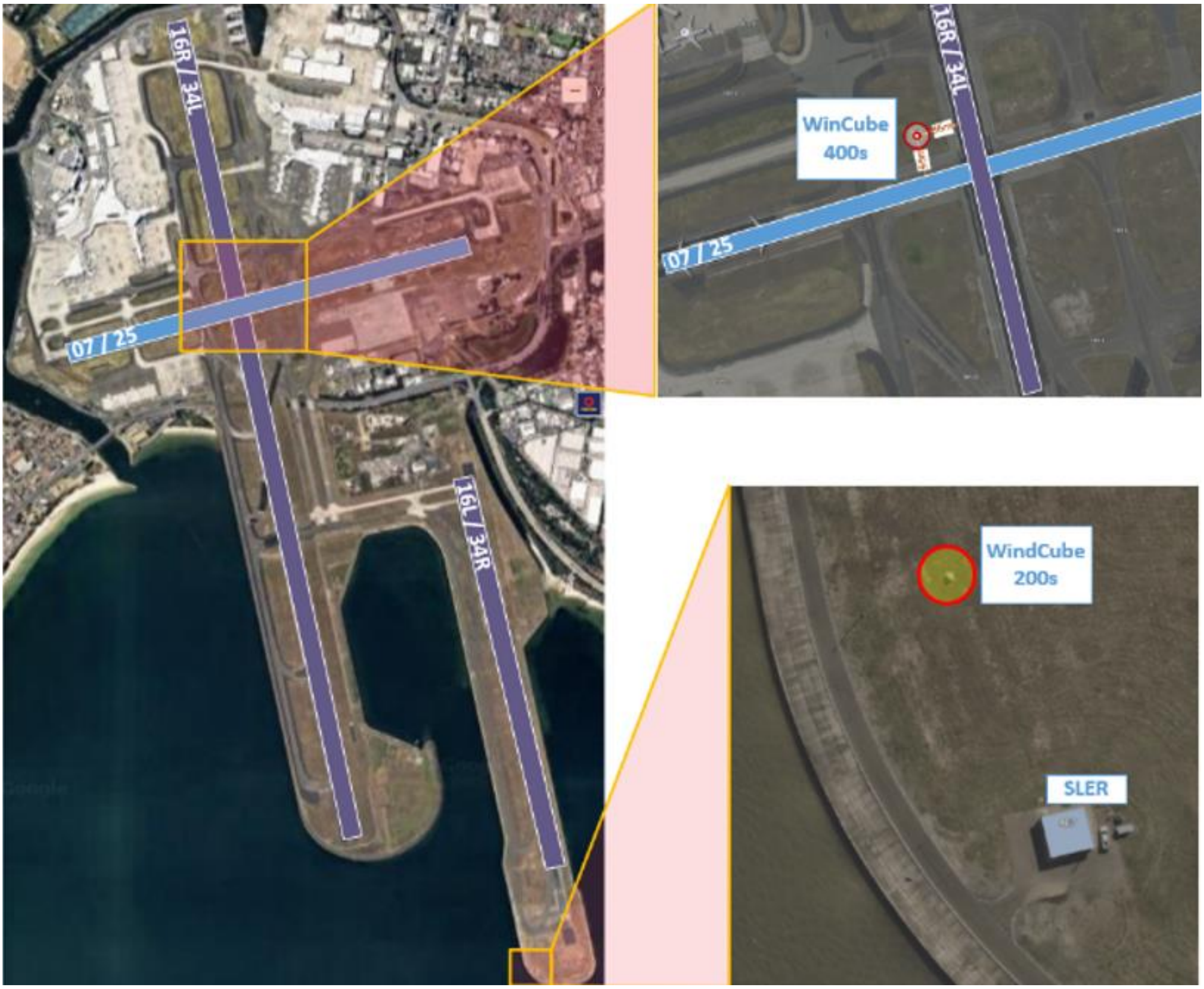
During the summer months, Sydney experiences a weather condition known as a Southerly Buster. The Southerly Buster is a cold front that sweeps up from the south and abruptly cools the temperature bringing thunderstorms, gale winds, and wind shear accompanied with a swift 180-degree wind change. The rapid change in wind direction not only creates a hazard to aircraft but also necessitates a switch in runway direction that can affect up to ten (10) aircraft being required to 'go-around' when a runway is reconfigured at short notice due to wind shear.

Thunderstorms and Microbursts

Microbursts are most often associated with thunderstorms. Thunderstorms are a frequent phenomenon at Sydney airport.

How does SYD alert aircraft to windshear?

The Light Detection and Ranging (LiDAR) units are used to measure the headwind profiles along the glide paths. The Low-Level Windshear Alerting System (LLWAS) detects significant changes in the headwind from the measured headwind profiles and issues windshear alerts. The SYD LLWAS is equipped with two LiDAR units, one located near the threshold of runway 34R and the other located near the intersection of runways 07/25 and 16R/34L, so that all runways are served by a dedicated LIDAR unit.



Location of LiDAR units at SYD

The data is fed in real time to the LLWAS, which is used to automatically integrate and generate "up-to-the-minute" alerts, when windshear is detected.

In addition, Bureau of Meteorology (or The Bureau) aviation meteorologists will issue wind shear warnings for observed, reported or expected wind shear at YSSY, and SIGMET (warnings) for observed or expected severe turbulence, based on the broad prevailing meteorological conditions and any aircraft reports provided by pilots through the air traffic controller.

Aircraft operating at SYD are alerted of low-level windshear and turbulence in two ways:

- Windshear alerts passed by air traffic controllers (ATC):
- Alerts of windshear, which are generated automatically by the LLWAS, are passed to aircraft via ATC.
- Windshear and turbulence warnings provided on Automatic Terminal Information Service (ATIS):
- Warnings of wind shear and/or turbulence, issued by the Bureau of Meteorology, are provided to, are provided to aircraft on ATIS.

What levels of windshear alerts are issued?

The LIDAR based LLWAS continuously monitors possible occurrence of windshear within 3 NM of the runway thresholds and issues alerts.

The LIDAR system installed at Sydney Airport has limitations. The LIDAR system operates best in clear air conditions but has range limitations in cloud and rain. The purpose of the LIDAR based LLWAS is to augment aircraft capabilities such as weather RADAR.

Alerts for windshear are classified into two levels: 'Microburst Alert' (MBA) and 'Windshear Alert' (WSA). This follows the same terminology adopted by the US Federal Aviation Administration (FAA) in classifying windshear alerts issued by the Terminal Doppler Weather Radar (TDWR) installed at major aerodromes throughout the US.

Microburst Alert (MBA):

Alerts for windshear with headwind loss of 30 knots or greater.

Note: The reporting of the wind shear event using "FAA Ribbon" message has its value rounded to nearest 5 knots.

For example: -28.1 knots shear value is rounded to -30 knots. The threshold for WSA/MBA is checked from the raw value, therefore -28.1 becomes "WSA 30K- ".

Similarly, -31.1 knots would be rounded to -30 knots, but as it exceeds the MBA limit, it would be reported as "MBA 30K- ".

Windshear Alert (WSA):

Alerts for windshear with headwind loss or gain of 15 knots or greater (except microburst). Note that the following will be issued as a WSA, not a MBA: (i) a headwind gain of 30 knots or greater;

The way in which an aircraft is affected by windshear is dependent on several important factors. These include the rate of change of wind speed, the total magnitude of the headwind/tailwind change, the airspeed of the aircraft, the distance over which the windshear operates, the aircraft type, and the aircraft response.

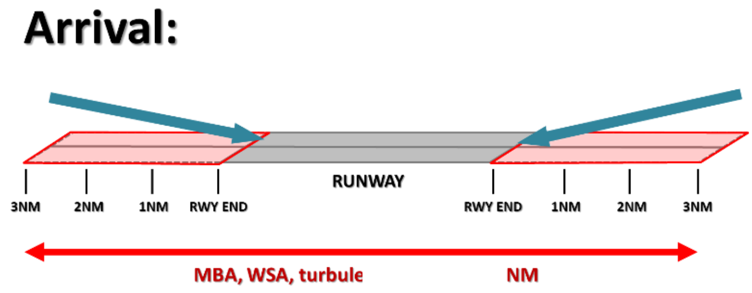
'MBA' is only a terminology to denote an alert generated by LIDAR when the headwind loss is 30 knots or greater. It may be caused by phenomena other than a 'conventional' microburst. As such, you should not expect the typical sequence of events in traversing a 'conventional' microburst (i.e. headwind gain and lift preceding a downdraft, followed by headwind loss and sink) to always occur when an MBA is in effect.

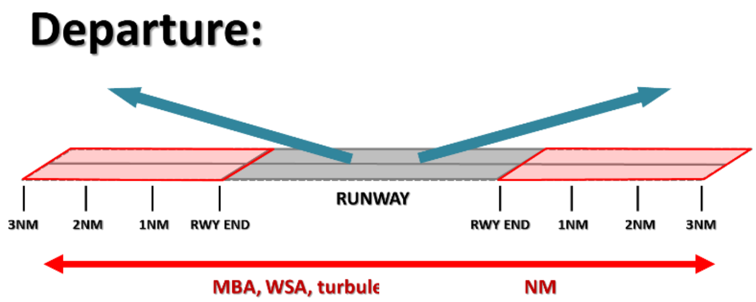
What is the coverage of the alerts?

Arrival corridors: Microburst and windshear events out to 3 NM will be alerted.

Departure corridors: Alerts of microburst and wind shear will be issued for events up to 3 NM.

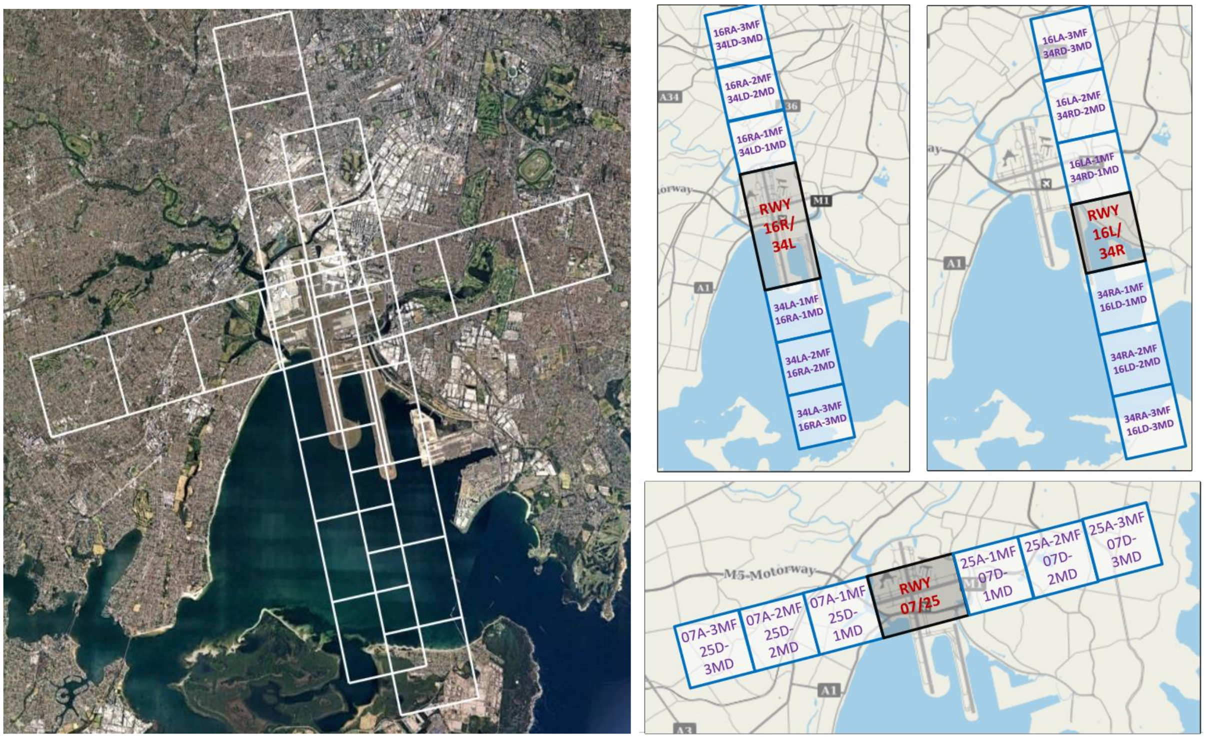
The spatial coverage of alerts of windshear and turbulence is summarised in the following diagrams:





Alerts will be generated on ARENA (Areas Noted for Attention). An ARENA extends on the runway centerline from a 3-mile final to the runway to a 3-mile departure.

Sydney Airport has a total of 21 ARENA, seven for runway 07/25, seven for runway 16R/34L and seven for runway 16L/34R.



What is the phraseology of windshear and turbulence alerts passed by ATC?

The Microburst Alert or Windshear Alert passed by ATC includes the type of alert (i.e. microburst or windshear), the magnitude of the runway orientated wind speed difference and the location (i.e. final approach, departure or runway area as appropriate) of the First Encounter in nautical miles.

The FAA phraseology that has been adopted is used at major US airports. It is based on the "First Encounter-Maximum Intensity" principle, where the location of the expected encounter with the first significant windshear event is reported along with the intensity of the maximum windshear event that is expected to be encountered.

Runway 34R Arrival Microburst Alert 30 knot loss 3 mile final.

In plain language, the controller is telling the pilot that on approach to Runway 34R, there is a microburst alert on the approach lane to the runway, and to anticipate or expect a 30-knot loss of airspeed at approximately 3 miles out on final approach (where it will first encounter the phenomena). With that information, the aircrew is forewarned, and should be prepared to apply wind shear/microburst escape procedures should they decide to continue the approach.

RWY 16L Departure Windshear Alert 15 knot gain 2-mile departure.

RWY 16R Departure Windshear Alert 20 knot loss on Runway.

What is the phraseology of windshear and turbulence warnings provided on ATIS?

A windshear warning provided on ATIS includes the type of warning (significant windshear) and the specific runway corridor(s) to which the warning is applicable.

- Significant windshear forecast 34L and 34R. Significant windshear forecast 25.
- Microburst and significant windshear 16L and 16R. Significant windshear 07.
- A turbulence warning provided on ATIS includes the intensity and type of warning (i.e. moderate or severe turbulence), and the relevant runway corridors.
- Moderate turbulence forecast 34L and 34R. Severe turbulence forecast 25.

A warning will be given as "forecast" when the information is forecast by the Bureau of Meteorology, or "forecast and reported" when the information has also been confirmed by a pilot or Aircraft Meteorological Data Relay Report (AMDAR) aircraft report.

Significant windshear forecast 34L and 34R.

(when windshear is forecastby Aviation Meteorological Forecaster for both RWY 34L and RWY 34R)

Significant windshear forecast and reported 34L and 34R.

(when the warning has been confirmed by a pilot or automatic aircraft report over either of the corridors)

Warnings given on ATIS are coded in ICAO abbreviations, e.g. "SIG WS

FCST AND REP 34L AND 34R" or "MOD TURB FCST 34L AND 34R".

In case more than one of the sub-systems detect windshear on the same runway corridor, what alert is issued?

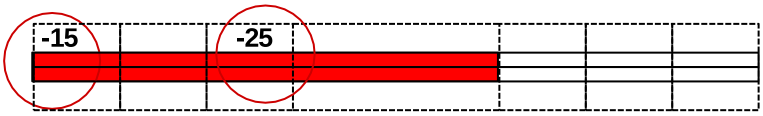
The LLWAS integrates real-time information from the LIDARs to generate automatic windshear alerts. When more than one event is detected within a particular runway corridor, a loss event will have higher priority over gain event.

The following priority scheme takes into account the severity of the alerts (microburst over windshear; loss over gain):

- (highest) Microburst (Loss of 30 knots or greater)
- Windshear of minus 15 knots or greater
- (lowest) Windshear of plus 15 knots or greater

The alert with a higher priority is issued and passed to aircraft by ATC.

If a windshear of minus 15 knots at 3 mile final and another windshear of minus 25 knots at 1 mile final are detected by the LIDAR, the alert provided is “Runway 34R Arrival, Wind Shear Alert, 25 knot Loss at 3NM Final” (i.e. First Encounter; Maximum Intensity.)



It should be noted that the alert refers to the maximum intensity of windshear events within 3 NM from the runway threshold. The reported intensity is the maximum loss or gain that may be encountered anywhere along the 3 NM corridor on approach or departure to the runway.

If a windshear of plus 20 knots at 2 miles final and another windshear of minus 20 knots at 1 mile final are detected by the LLWAS the alert provided is “Windshear Alert minus 20 knots at 2 nm on final approach”.

Pilots should note that gain and loss events can co-exist on the same arrival or departure corridor. This means that while a windshear alert of wind loss is given to the aircraft, you may also encounter a wind gain event.

If an MBA of minus 30 knots at 1 mile final is generated and a WSA of plus 15 knots at 3-mile final is generate, only the MBA will be issued.

Typical causes of windshear and turbulence at SYD

Most windshear and turbulence at SYD are caused by strong winds blowing from the south or west. Easterly winds (sea breeze) can generate wind shear and mechanical turbulence due to the proximity of Port Botany. Other events based on pilot reports can be attributed to meteorological factors such as gust fronts, microburst events, low level jet streams and building-induced turbulence.

Apart from terrain, buildings, and man-made structures (such as Port Botany) may also lead to turbulence at SYD under “favourable” wind speeds and/or directions. Moreover, under certain atmospheric conditions, wake turbulence, a disturbance caused by an aircraft in flight, might dissipate slower than the norm leading to significant turbulence encountered by the following aircraft.

These factors are elaborated in the following pages.

SYD

How changeable is windshear in Sydney?

It should be noted that:

Runway gain and loss events can co-exist on the same corridor.

While windshear alert of wind loss is given, you may also encounter a wind gain event.

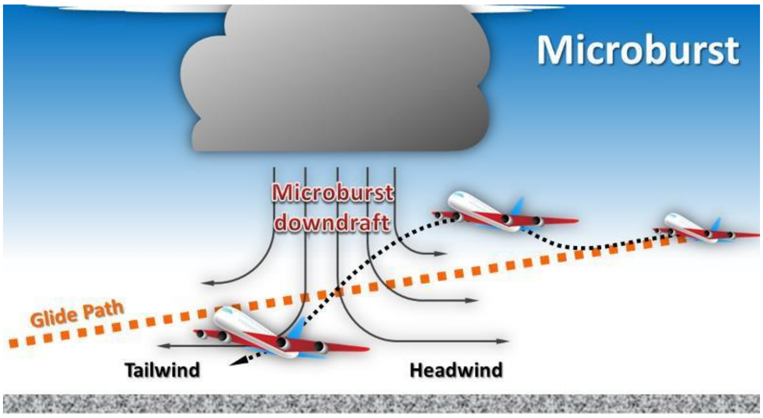
Due to the transient and sporadic characteristics of windshear, a headwind loss/gain may not necessarily be followed/preceded by a headwind gain/loss.

The sequence of events (e.g. headwind loss followed by headwind gain, or vice versa) may be experienced differently by successive aircraft.

Some aircraft may experience windshear and turbulence, while others do not, even though the weather conditions are broadly the same.

What is a ‘microburst’?

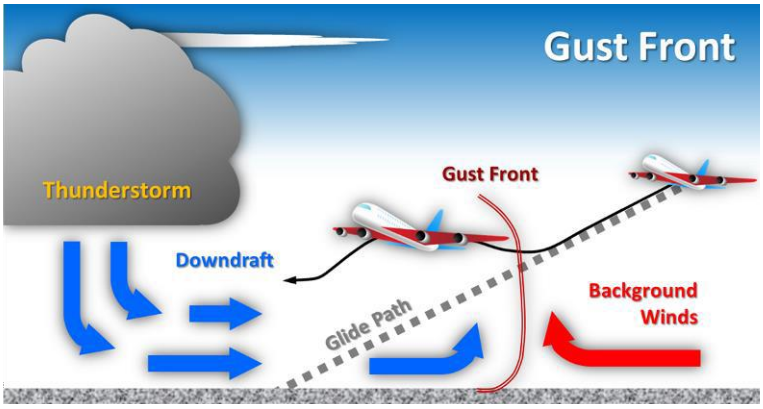
Microburst is the most violent form of downdraft from a thunderstorm. It is characterized by an intense and localized descent of cool air, causing a sudden outflow of horizontal winds above the ground with a typical horizontal extent of a few kilometers. An aircraft flying through a microburst may first encounter an increasing headwind and lift, then a downdraft from above the aircraft, followed by an increasing tailwind and sink. To overcome the adverse effect of the microburst, the pilot needs to take timely corrective action to ensure aircraft safety.



Well, that is the ideal theoretical world, though it can happen like this in practice, as some pilots have experienced. The first point, however, is that microburst can be asymmetric, having winds on one side stronger than the other side. The second point is that the column of downdraft can hit the ground at an angle, rather than vertically downward. So, if you are carrying out an approach through a microburst, you may not encounter the “classic” headwind gain and lift prior to the downdraft and headwind loss.

What is a ‘Gust Front’?

Severe thunderstorms are associated with intense convection, often resulting in violent downdraft and heavy rain. The descending air is cool and dense, and spreads out on hitting the ground. The leading edge of the cool air is called the gust front. Aircraft flying across a gust front may encounter increased headwind and lift.



Gusty westerly winds can be more common at Sydney Airport in spring

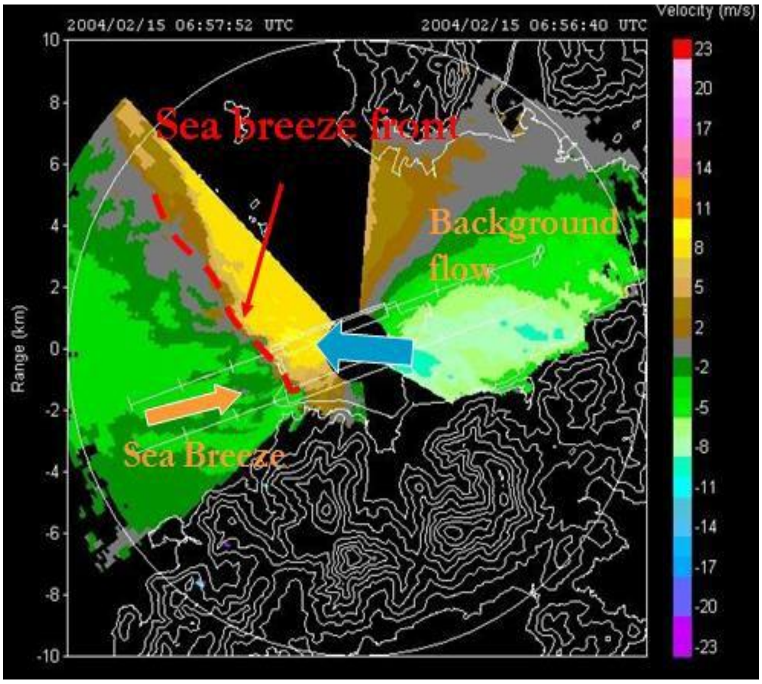
What is ‘sea breeze’?

Sea breeze usually develops under fine weather and light wind conditions when cooler and denser air over water flows towards warmer and less dense air over land due to the differential solar heating between the sea surface and the landmass (see the first headwind profile example on page 5). At SYD, the onset of sea breeze is typically characterized by winds turning westerly over the western part of the airport. With prevailing easterly winds blowing in the background, significant windshear in the form of headwind gain to an aircraft may develop along the runways. Similarly, with prevailing west to southwesterly winds blowing in the background, sea breeze may appear as easterly over the eastern part of the airport. It should be noted that headwind loss may also occur for windshear associated with sea breeze due to the complex vertical structure of the interface between the sea breeze and the background wind.

While not frequent, windshear of 20 knots or greater associated with sea breeze may occur under background winds of 10 knots or higher.

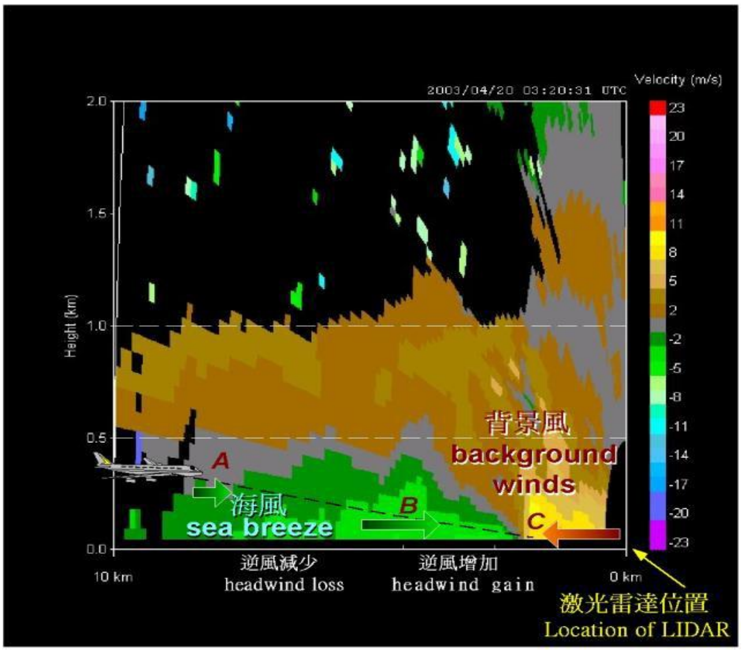
Turbulence, in addition to windshear, is also known to occur in a sea breeze.

A typical example of windshear associated with sea breeze is shown in the LIDAR scan below. LIDAR is good at capturing sea breeze front, which occurs in mainly fine weather. (Note: this image is taken at HKIA.)



LIDAR image on 15 February 2004. The cool/warm colours represent winds towards/away from the LIDAR (see scale on the right). The dashed line represents the boundary, viz. the sea breeze front, where the background easterly met the westerly brought by the sea breeze.

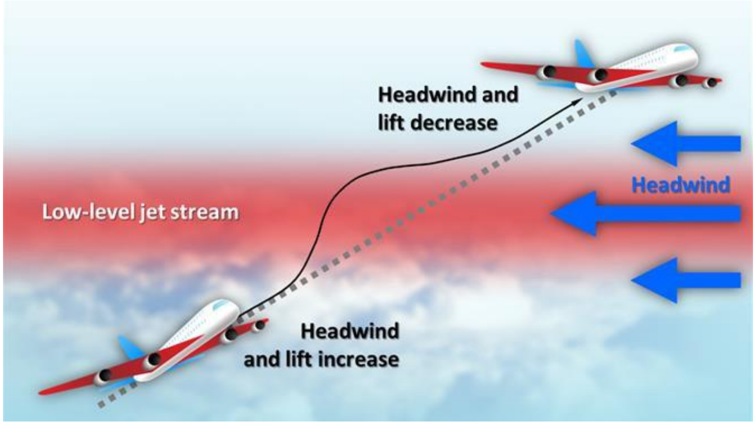
The complex structure of the sea breeze front is shown in the vertical scan of the LIDAR below. As the aircraft descents on the glide path from A to B, it would experience headwind loss with the wind changing from the background easterly to the westerly brought by the sea breeze. When the aircraft descends further from B to C, it would experience headwind gain with the wind changing from the westerly back to the background easterly.



Vertical cross section image of the LIDAR on 20 April 2003. The black dashed line indicates the descending glide path. The grey band (near zero wind speed) separates the sea breeze beneath (cool colour) and the background wind aloft (warm colour).

What is 'low-level jet'?

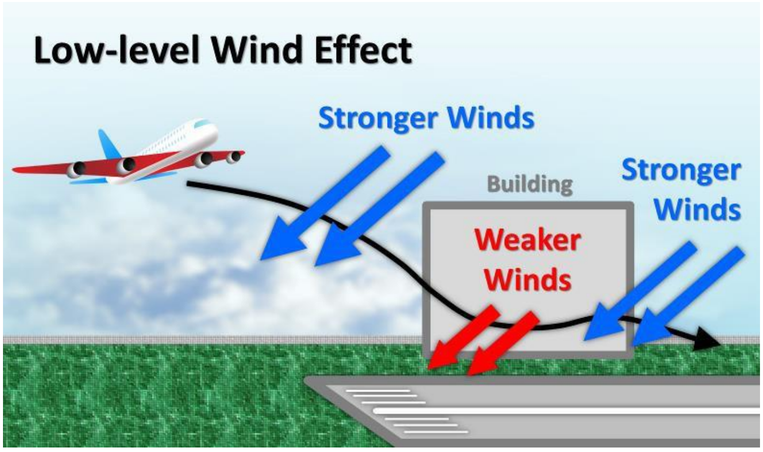
A low-level jet is a narrow band of strong winds in the lower atmosphere. Windshear arising from a low-level jet is relatively infrequent at SYD. When an aircraft departing from the airport ascends and enters the jet, it experiences increasing headwind and lift. As it departs the jet, however, the headwind and lift decrease.



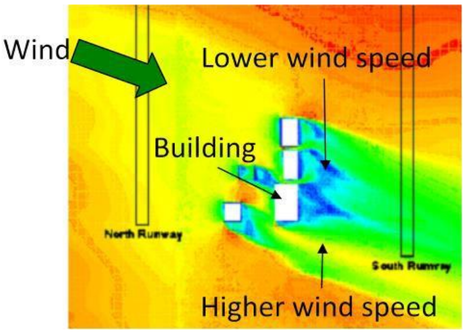
A landing aircraft passing through a jet will also encounter the same sequence of headwind changes, because it is usually flying against the prevailing wind. However, since a landing aircraft is usually descending on a 3 degrees glide path compared with the higher climb gradient of a departing aircraft, the headwind changes it would experience is generally "gentler" than that for a departing aircraft.

What is 'low-level wind effect'?

Low-level wind effect, or building wake, refers to significant airflow disruption due to buildings and other man-made structures close to the runway, leading to turbulence, crosswind changes and possibly windshear under certain wind conditions.



As the air flows over a building, depending on the background wind speed and direction, the stability of the atmosphere and the size of the building, the air may be blocked, flow over or around the building. This is similar to the occurrence of waves and vortices downstream of a stone in a river.



If the building is rather close to the flight path and is sufficiently large, it may bring about rapid fluctuations of the wind that are perceived to be wind changes (headwind/crosswind changes) and/or turbulence by the pilots.

When the low-level wind effect causes the crosswind component to fluctuate, pilots may experience control difficulties during take-off and landing. Under such conditions, directional control would be more challenging on a wet runway.

There is the possibility of encountering building-induced turbulence and windshear when landing on RWY 16R in strong westerly winds; or landing on RWY 34R in strong easterly winds.

What are the other possible causes of windshear/ turbulence events?

Sydney Airport has also conducted the first series of aircraft wake vortex (or wake turbulence) measurements. In addition to providing input to studies on Recategorization of ICAO wake turbulence separation minima (RECAT) for possible future enhancements of air traffic flow capacity, there are also instances observed where remnant wake turbulence airflow combines to create conditions conducive to actual windshear reports. Sydney Airport will conduct further scientific studies of such phenomena and bring the results to the attention of pilots as they become available.

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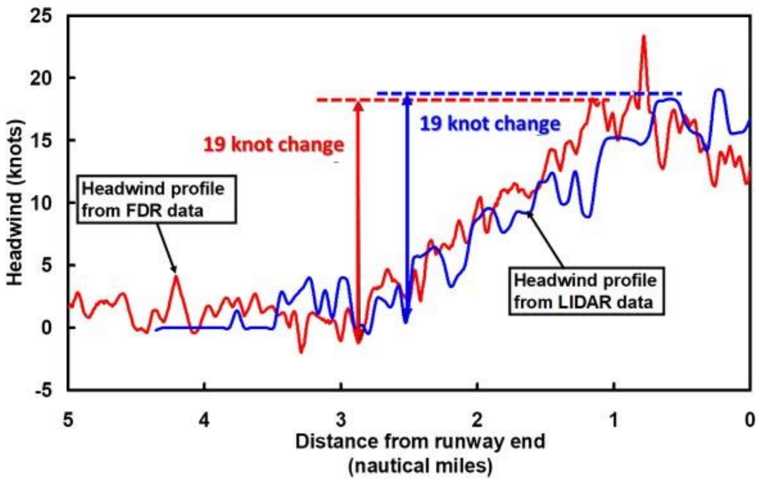
Why is the alerted windshear sometimes not experienced, and vice versa?

The first possibility is the transient and sporadic nature of windshear and turbulence. The windshear feature may affect a particular runway corridor for a short period of time and thus is not experienced by all aircraft operating over that corridor.

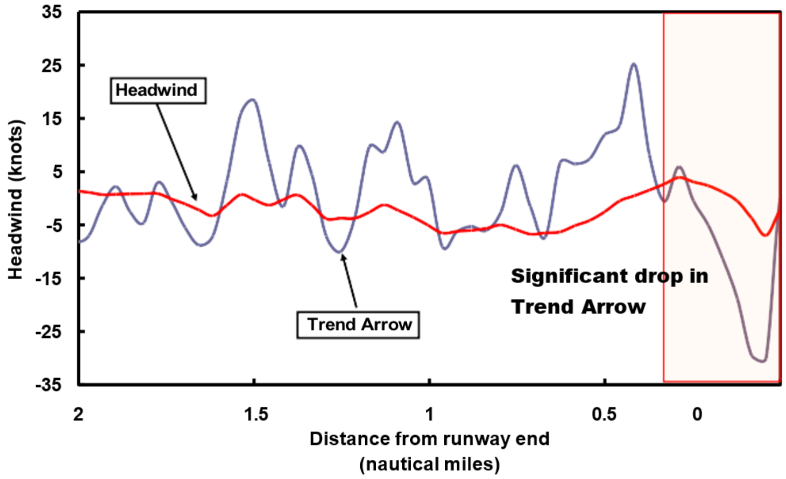
Moreover, studies of null reports from pilots together with weather data have revealed that pilots tend not to report or report less for windshear with length-scale near the higher end of the horizontal spatial scale, i.e. between 3 and 4 km. It is not practical to remove the alerting of "gentle windshear" events altogether because they are still considered to be significant in quite a few pilot reports.

The figure below shows a case of "gentle windshear". The aircraft FDR data and the LIDAR data are consistent with each other, both indicating the occurrence of significant windshear of comparable magnitude. The pilot however reported no windshear in this case.



The “gentle windshear” may not be regarded as significant particularly for departing aircraft because the aircraft is normally in takeoff thrust and wind speed increasing with altitude is generally expected to occur. As such, LLWAS has already used different length scales for windshear detection over the arriving and departing runway corridors, with a shorter length scale being employed for the departure corridors.

Furthermore, discussions with pilots in various occasions suggest that low-level windshear might be reported by referring to elements in addition to the headwind changes, such as the on-board “Speed Trend Arrow” available on the Airbus Primary Flight Display. The Trend Arrow is determined based on the past wind data an aircraft has just experienced and represents the projected wind change in the next several seconds the aircraft might experience. Studies using aircraft flight data have indicated that the Trend Arrow might sometimes over-estimate the actual wind speed change that an aircraft would encounter. The figure below shows an example in which the pilot reported significant windshear possibly based on the Trend Arrow information, but the actual headwind loss was less than 15 knots.



Notes to pilots

In summary, there are a number of important points to note:

Windshear associated with an "MBA" may be caused by phenomena other than a microburst in the conventional sense. Pilots should not expect the typical sequence of events in traversing a 'conventional' microburst (i.e. headwind gain and lift preceding a downdraft, followed by headwind loss and sink) to occur every time the MBA is in effect.

Multiple occurrences of windshear/turbulence on the same runway corridor are consolidated to generate a single windshear/turbulence alert. Remember that the first encounter may not be the worst encounter. There may still be windshear/turbulence events after the first encounter.

Gain and loss events can co-exist on the same runway corridor, particularly for terrain-induced windshear. While a windshear alert of wind loss is given, you may encounter a wind gain event as well.

Most windshear and turbulence, at SYD, are caused by strong westerly or southerly winds.

Whenever an "MBA" or "WSA" is in effect, particularly for windshear gain or loss of 30 knots or greater, you are advised to avoid entering into the microburst or windshear region.

Further information

For more information on the windshear and turbulence alerting service in Sydney, please visit SYD’s website at:

https://www.sydneyairport.com.au/

You may also refer to section GEN 3.5 in the Sydney, Kingsford Smith Aeronautical Information Publication (AIP) which is available at:

https://www.airservicesaustralia.com

More information on windshear, particularly the effect of low-level windshear on aircraft performance, can be found in:

ICAO Manual on Low-level Wind Shear and Turbulence (Doc 9817)

US Federal Aviation Administration’s Advisory Circular No.00-54 “Pilot Windshear Guide” (1988)

HKO/IFALPA/WMO/ICAO Windshear Posters, available at:

https://www.hko.gov.hk/en/aviat/ws_poster/ws_poster.htm

Pamphlet on “Low Level Wind Effect At Airports”, available at:
https://www.hko.gov.hk/en/aviat/articles/files/ llw_pamphlet_3col_v17.pdf

The Bureau of Meteorology website available at:

http://www.bom.gov.au/aviation/data/education/wind-shear.pdf