

# WEATHER ADVICE FOR YOUR SAFETY

## Flying the Tropics

Bureau of Meteorology › Weather Services › Aviation



This pamphlet provides an overview of the weather over the Australia Tropics (defined as north of latitude 23.5 degrees South), particularly as it affects aviation.



**Weatherwise pilots keep in touch with the current and expected weather patterns by:**

- **obtaining the latest aviation observations, forecasts, warnings and charts from the briefing system listed at the end of this pamphlet,**
- **telephoning the Bureau of Meteorology for elaborative briefing, when appropriate, and**
- **paying attention to media weather presentations and reports.**

**Pilots also benefit from understanding the characteristics of particular weather situations and systems which affect the area in which they operate. This pamphlet discusses some of the hazardous weather elements and situations that may be experienced in southeastern Australia from an aviation perspective.**

### General Climate

Flying conditions over the Australian tropics vary considerably in time and space. Whilst good flying weather conditions exist over the area for long periods, conditions do occur which may necessitate significant deviations from planned tracks, or result in lengthy delays on the ground. Tropical cyclones, deep monsoonal troughs, active thunderstorm zones and moist onshore winds are all capable of producing hazardous flying conditions.

### The Wet Season

Most of the hazardous aviation weather in the tropics occurs during the wet season, which generally extends from October to April. It is a time of unstable atmospheric conditions due to high humidity and temperatures.

Tropical cyclones and active monsoon troughs may produce heavy rainfall for prolonged periods, squally winds and thunderstorms. The build-up to, and break periods within, the monsoon are characterised by isolated afternoon and evening thunderstorms, although occasionally the thunderstorms are frequent and may exist in lines which can extend to hundreds of kilometres and travel westward for several days. You should pay attention to forecasts and warnings and seek elaborative briefings if in any doubt.

Break periods within the wet season are characterised by a weak heat trough that can bring afternoon and overnight thunderstorms.



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## The Dry Season

During the dry season, typically May to September, prevailing flying conditions are generally good, however meteorological hazards to flying do occur. These include poor visibility in smoke and haze from bushfires; coastal showers in onshore winds (particularly where they are enhanced along the Great Dividing Range in northern Queensland); turbulence arising from a low-level jet through central northern Australia; fog; and extensive cloud bands which generally affect inland areas of central Australia.

## The Transition Periods

The transition periods between the two distinct seasons are also known as the pre and post-monsoon periods. The pre-monsoon period is also referred to as the build-up because of the gradual increase of the convective cloud and humidity before the monsoon onset. It typically extends from September to early November. The post-monsoon period is usually much shorter and occurs mostly during April. During the transition periods, elements of either the dry or wet seasons may be experienced. A weak heat trough often develops, bringing afternoon and overnight thunderstorms.

## Significant Weather Systems

### Tropical Cyclones

The tropical cyclone season extends from November to April. Tropical cyclones are non-frontal low pressure systems of synoptic scale developing over warm waters, with organised convection and a maximum mean wind speed at the surface of at least 34 knots extending more than half-way around the centre and persisting for at least six hours. Spiral rain-bands are generally confined within a few hundred kilometres of the centre but may extend out to 1000 kilometres from the centre. The weather associated with a cyclone's coastal landfall includes high winds, severe horizontal and vertical wind shear, heavy rainfall and associated low cloud and reduced visibility. This is generally confined to within a hundred kilometres of the coast as cyclones generally weaken rapidly on landfall; however in some cases they can maintain cyclone intensity far inland. After landfall, the cyclone will quite often form an extensive rain depression which presents very hazardous conditions for aviation.

Details of the extent, movement and trend of a particular tropical cyclone are contained in Area Forecasts and SIGMET.

Any part of the northern Australian coastline can be affected by tropical cyclones. The north-west coast of Western Australia is the area of highest overall frequency and severity.

### The Monsoon

The onset of the monsoon brings a change from a diurnal isolated thunderstorm pattern to one characterised by episodes of heavy rain from stratiform cloud (with associated lower cloud and poor visibility), embedded thunderstorms and squally showers. On mean sea-level pressure (MSLP) charts, a monsoon trough is usually evident. The trough separates a low-level west to north-westerly flow (from equatorial regions to the north of the trough) from relatively dry southeasterly flow (to the south of the trough). Major weather systems may exist along the monsoon trough. Watch for a monsoon low, a system which has many of the characteristics of tropical cyclones except for the extreme winds near the centre. These lows usually bring extensive low cloud and reduced visibility in heavy rain.

Active periods of the monsoon occur, on average, two to three times each wet season, and lasting one to two weeks. The first burst of the active monsoon in north and west Australia often occurs in late December, and then in January in north Queensland. During the middle of the wet season (January to March) the monsoon trough can move inland (possibly up to a thousand kilometres or more) bringing heavy rain and low cloud to places such as Tennant Creek. During the monsoon there can be periods of up to a week of gale force (at least 34 knots) westerly winds at exposed coastal locations. Squally rain showers can result in wind gusts of up to 50 knots at places like Darwin, Weipa and Broome. Aerodrome Warnings for gales are issued for Darwin, Cairns, Townsville, Mackay and Hamilton Island Airports.



Tropical Cyclone *Larry* approaching the Queensland coast.



## Heat Trough

The heat trough is a semi-permanent feature across north and central Australia during the transition periods and the break periods in the wet season. This trough separates the moist and potentially unstable air mass in the north from dry and generally more stable conditions in the south. The position of the trough can fluctuate depending on surges of mid-latitude air. Weather on the heat trough is predominately afternoon and overnight thunderstorms.



MSLP chart showing active monsoon trough.



MSLP chart showing heat trough

## Hazardous Phenomena

### Cloud Bands

The dry season regularly sees narrow elongated cloud bands develop in association with atmospheric features at higher latitudes. Typically they extend from off the northwest coast towards the southeast. The cloud is mostly stratiform at middle levels. These bands tend to move slowly eastwards across the region, and may bring significant rainfall to tropical and inland areas. When steady and significant rainfall does occur it is likely to be accompanied by extensive low cloud and often followed by fog. Elevated areas such as Alice Springs are very prone to extensive areas of low cloud in the southeast flow following a cloud band.

### Thunderstorms

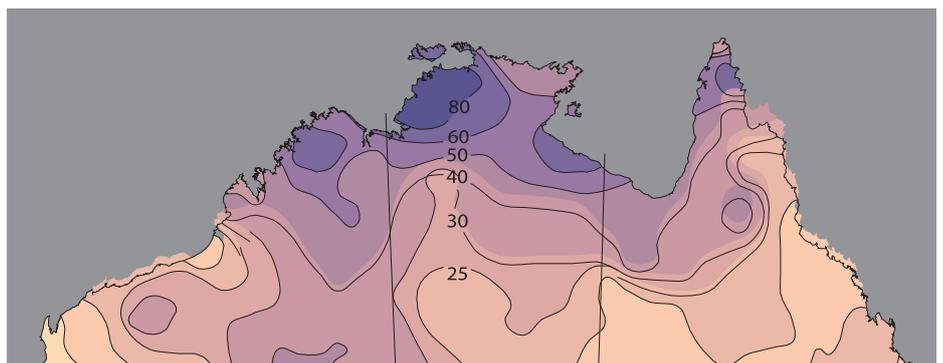
Thunderstorms are a very frequent and widespread hazard during the wet season. They are common during the late afternoon and early evening, with a secondary peak in the early morning.

The tops of tropical thunderstorm clouds reach much higher altitudes (often exceeding 45 000 feet) than those of temperate latitudes. They often spread out to form sheets of altostratus and cirrostratus clouds late in their life cycle, bringing steady overnight rain and low cloud persisting into the morning. As a thunderstorm is growing, updrafts in the core can reach over 100 knots. These updrafts can exist alongside downdrafts of similar strength as rain starts to fall out of the storm, resulting in potential for severe turbulence and loss of aircraft control if flying into such conditions.

Pilots may face lengthy diversions especially when the thunderstorms are part of a roadscale synoptic feature. Some areas, such as the Kimberley, Arnhem Land, Cape York Peninsula and the ranges adjacent to the north Queensland coast, are prone to lines of thunderstorms which can often extend up to 200 kilometres in length (and occasionally as much as 300-400 kilometres) and travel for several days. SIGMETs are issued for obscured, embedded, frequent and squall line thunderstorms; and Aerodrome Warnings are issued for selected airports if a significant thunderstorm



Thunderstorm over Darwin, courtesy, Tourism NT.



Average annual thunder-days.

0 5 10 15 20 25 30 40 50 60 80

is likely to pass over the airport. Darwin only issues aerodrome warnings for thunderstorms if wind gusts in excess of 42 knots are expected.

Thunderstorms over inland Queensland, the Northern Territory and Western Australia usually develop along the semi-permanent inland heat trough, with maximum development generally occurring in mid-afternoon. The convective cloud bases can be very high (sometimes up to 15 000 feet), with very severe downdrafts from the cloud base to the surface. For this reason flights should never be conducted under or through precipitation (including virga) from towering cumulus or cumulonimbus clouds.

Thunderstorms in the transition periods tend to be more isolated than during the wet season. Keep in mind that these frequently have high bases, flying below which may result in strong downdrafts being encountered.

One final hazard associated with tropical thunderstorms is large hail. Above the freezing level hail size can be significant (tennis ball size) due to high precipitable water content and plenty of time for hail growth. Forecasts will warn if hail is an expected hazard with thunderstorms.

The peak frequency of thunderstorms is in the vicinity of Darwin with over eighty thunder-days per year. Thunderstorm frequency decreases in the southern parts of the tropics except over inland Western Australia. There is a low frequency of thunderstorms in the very wet section of the Queensland coast between Cooktown and south of Innisfail due to the combination of the orographic influences driving rainfall and the stability of the southeast trade winds for much of the year.

### Downbursts

The outflow from a storm's downdraft will occasionally produce winds of destructive force and shear which can present a very serious hazard to aircraft operations at low altitudes and on the ground.

When precipitation falls into drier air inside or below a thunderstorm, it immediately begins evaporating. This evaporation cools the surrounding air, increasing its density, causing it to accelerate downwards. This concentrated downdraft is called a downburst, which typically lasts five to fifteen minutes, and is of such high speed that it can cause damage on, or near, the ground.

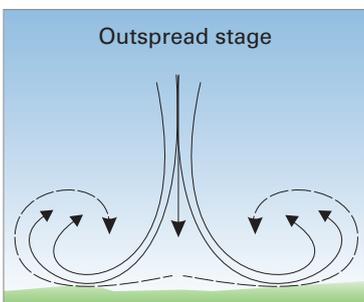
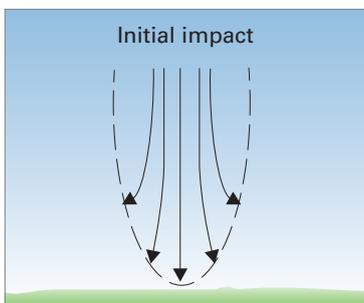
The term **microburst** is used to describe a downburst which causes damage over an area with horizontal dimensions of less than four kilometres.

Any convection in the atmosphere presents the potential for downbursts. They may be associated with heavy convective precipitation or there may be little or no rain reaching the surface (a dry downburst).

Downburst winds originate from the cloud base and diverge when they make contact with the ground. The rapid change in wind speed and direction associated with downbursts poses a threat to aircraft during take-off and landing phases, during which an aircraft will typically first encounter a strong headwind, then a downdraft which is the vertically descending section of the downburst, and finally a region of strong tailwind. If a pilot was to over-compensate for the lift experienced in the headwind, a dangerous drop in altitude may occur when the lift disappears in the downdraft and tailwind regions.

Recent studies with Doppler radar in Darwin indicate the frequency of downbursts is relatively high during the wet season and the transition periods. It is reasonable to assume this relatively high frequency of downbursts applies right across the tropical areas of Australia at these times, when convectively unstable conditions prevail. Because of the short life span of downbursts and their limited horizontal extent, it is not possible to forecast their occurrence. It is imperative therefore that pilots be aware of any clues, visual or otherwise, that may suggest the potential for downbursts upon departure or approach. Some clues to look for include:

- blowing dust, particularly if it has a circular pattern.
- virga (precipitation not reaching the ground), particularly if the cloud base is high and the sub-cloud layer hot and relatively dry.



Schematic of a downburst.

- precipitation from convective cloud, particularly if a curling outflow is evident near the surface.
- reports of hazardous wind shear from other aircraft operating in the area.
- unusual vertical airspeed fluctuations during take-off or final stages of landing.

### Low Cloud and Showers

Virtually any part of the tropical coast and nearby ranges may experience persistent low cloud in moist onshore winds. Pilots planning visual flights should take care to relate forecast cloud base to lowest safe altitude, especially where airspace restrictions apply. Moist onshore winds often produce frequent shower activity with the main cloud base around 2000 ft. Significant reductions in cloud base and visibility will occur in heavy showers, compounding the difficulty of flying in the high volume traffic along the coast.

During the cooler months, onshore winds consistently push moisture into the coast, particularly along the Queensland coast where the southeast trade winds are prevalent. The inflow of moisture from these onshore winds often results in diurnal showers and low cloud, peaking overnight and morning then weakening during the afternoon. Scattered cumulus cloud forms around the coast in the trade winds on most days; however strong and deep trades produce prolonged poor flying conditions especially where the ranges are close to the coast.

During an active monsoon where the westerly winds are near gale force, fast moving squally showers may temporarily reduce visibility and produce severe wind gusts.

### Rain Depressions

Rain depressions that have formed from tropical cyclones, or are low-pressure systems over land embedded in the monsoon trough, may be associated with extensive areas of low cloud, precipitation, reduced visibility and turbulent flying conditions. The low cloud may persist for twenty four hours or so after the rain has stopped, especially near a decaying trough. In all these cases, carefully consider the lowest safe altitude before attempting to fly below a low cloud base, as inland areas may not always be as flat as first appears.

### Volcanic Ash

Although a fairly rare possibility, there is potential for a volcanic ash cloud, which can cause significant damage to aircraft, to drift into the Australian tropics from Indonesia, Papua New Guinea or South America. Volcanic Ash Advisories and SIGMETs will warn of volcanic ash.

### Smoke and Haze

Smoke and haze from bushfires are common during the dry season and frequently create navigational difficulties for VFR pilots. It is possible to encounter a reduction in horizontal and angular visibility to less than ten kilometres, and sometimes a reduction to two kilometres. If a low-level temperature inversion is trapping smoke in the underlying cooler air, flight above the inversion usually results in better horizontal visibility.

### Duststorms

Duststorms are most frequent in winter in eastern parts of the tropics, tending to occur more toward late spring and summer in western parts. They are a relatively infrequent phenomenon, becoming more frequent in drought years when they can occur at any time.

Duststorms can reduce visibility dramatically over a wide area, generally of the order of six to eight kilometres. Occasionally duststorms may reduce visibility to a few hundred metres.

Isolated duststorms may be associated with intensive heating, fresh winds, and downdraughts from thunderstorms. However duststorms covering huge areas appear as a wall-like boundary in the desert areas of central Australia. They are usually linked to cold fronts over southern Australia. Elsewhere they may be associated with tropical cyclones that penetrate well inland, or with trade wind surges.



Heavy shower on Melville Island, Northern Territory, photograph by Mike Rosel.



Sarychev Volcano, Kuril Islands, 2009, courtesy of NASA.



Dust storm, Moombidary Station, near Hungerford, Queensland, photograph by Helen Clifford.

## Dust Devils

Dust devils are visible as wind vortices lifting dust from the surface with diameters usually less than one hundred metres, but can extend up to a few thousand feet. They are a common occurrence throughout inland Australia, especially during the warmer months, and are dangerous to aircraft during take-off and landing.

## Low-level Jet Stream

Low-level jet streams frequently form in tropical inland parts of central Australia in the early morning in winter and persist until mid-morning. They occur mainly below 3000 feet above ground level when winds are calm, or very light, at the surface. Typical wind speeds in the jet may be 25 knots, although up to 50 knots may be experienced. The low-level jet stream often brings hazardous low-level wind shears. Tennant Creek, Mount Isa, Camooweal, Kununurra and Halls Creek are particularly prone locations.

## Thermal and Mechanical Turbulence

During the summer months temperatures in central Australia are frequently in the high 30s to low 40s degrees Celsius. This heating produces convective thermals during the daytime, resulting in moderate to occasionally severe (extremely uncomfortable) flying conditions below 15 000 feet.

Mechanical turbulence can result from strong winds at ridge top level. The McDonnell ranges in central Australia is one feature which frequently causes turbulent conditions. A strong northerly wind in spring is one such occasion where Alice Springs airport will experience moderate to occasionally severe turbulence.

## Fog

Fogs in tropical Australia are most common near the coast in the dry season. Fogs are reported from coastal stations in Western Australia (e.g. Broome and Port Hedland) about fifteen times a year. Fogs also occur in north Queensland, more commonly about the coast and during the cooler months. The number of fogs occurring is largely dependant on the airport location. Fogs can be expected at Rockhampton more than thirty times each year while at Cairns they are very rare. Radiation fogs forming in tropical areas are often shallow and do not significantly affect aviation operations. A few times each year, sea fogs form along the coast and persist for much of the day. Sea fogs are a regular occurrence during the dry and transition seasons about the Gulf of Carpentaria coast and frequently affect aerodromes such as Ngukurr, Borroloola and McArthur River Mine. Fogs and low stratus also occur about coastal valleys in the Northern Territory's top end during the dry season, occasionally extending as far inland as Tindal.

During the cooler months, low stratus or fog may be a problem in the days following rain, especially in the first couple of hours after sunrise. Although these fogs are generally only a few hundred feet deep, a runway visible on base leg approach can disappear on final due to reduced slant visibility.

## Morning Glory Cloud

The Morning Glory Cloud is a roll cloud which is believed to form in the convergence of the prevailing south-easterly trade wind and the Cape York east coast sea breeze. The cloud then moves westward over the southern Gulf of Carpentaria and adjacent coast during the night and early morning. Precipitation is rarely present, however it is often accompanied by a sudden wind squall, wind shear and a sharp pressure jump at the surface. The surge may trigger nocturnal thunderstorms when atmospheric stability is favourable.



Sun shines through fog on the Great Northern Highway, east of Broome, photograph by Mike Rosel.



Morning Glory Cloud over the Gulf of Carpentaria and adjacent coast.



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