Meteorology for Skydivers

Thesis Project by Archie Jamieson 2010

A useful guide to assist skydivers to gain information on weather forecasts and how to make practical use of it while at the Drop Zone.

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Introduction

The weather affects everyone from all walks of life. It is our constant companion - as tranquil, as turbulent, as wondrous and sometimes as unpredictable as life itself.

As skydivers, we are totally dependent on the weather to have our fun or to make a living. Yet over the years I have seen many jumpers that seem to have very little knowledge about this vast and fascinating subject. Let’s face it, all our lives to a certain extent depend on the weather. Just ask someone who has been stuck in a thunderstorm or perhaps been injured jumping in windy or turbulent conditions.

It is not the aim of this manual to teach you everything about Meteorology, the subject is simply too vast. However, it is the aim of this manual to give you a basic understanding of how to obtain and interpret the necessary information to make the decisions you need to make in your skydiving career; whether it is to alter the spot or put your gear away and go to the bar. It doesn’t matter if you’re an AFF student or a DZSO you need to be able to make informed decisions about the weather.

Meteorology is one of the oldest sciences and also one of the most challenging. There is a wealth of information available at your fingertips since the advent of the internet. Websites such as weatherzone.com and the Bureau of Meteorology (BOM) (www.bom.gov.au) can be extremely useful for obtaining forecasts. But there is nothing like looking out the window and up to the sky to see what is really going on. This manual will also give you a guide as to what you should be looking for once you arrive at the drop zone or before you take off on each and every load.

I hope this manual will enable you to experience the excitement of unravelling the mysteries of nature that is the privilege of all those of us who work with the weather.

Archie Jamieson.
AFFIB486 TM191

Where can I get the Information I need?

Websites

In today's technology filled world there is a lot of information available at your fingertips.

The four most valuable websites are:

- **Air Services** http://www.airservices.com.au forecasting for the upper winds;
- **Bureau of Meteorology** (BOM) http://www.bom.gov.au forecasting and actual ground wind information at various locations around the country;
- **Elders Weather** www.eldersweather.com.au A simple, user friendly informative site; and
- **Weatherzone** www.weatherzone.com.au A full service weather site with historical records of wind from the previous 24hours and live satellite and radar pictures.

These websites provide many services that are incredibly useful to the skydiver. These include:

- Radar images - To detect areas of rain, though not Cloud;
- Satellite images;
- Infrared Images - Cloud contains moisture & hence is cooler and detectable;
- Visual Images (Cloud Photos);
- Short & Long Term Forecasts;
- Weather charts; and
- Synoptic Charts.

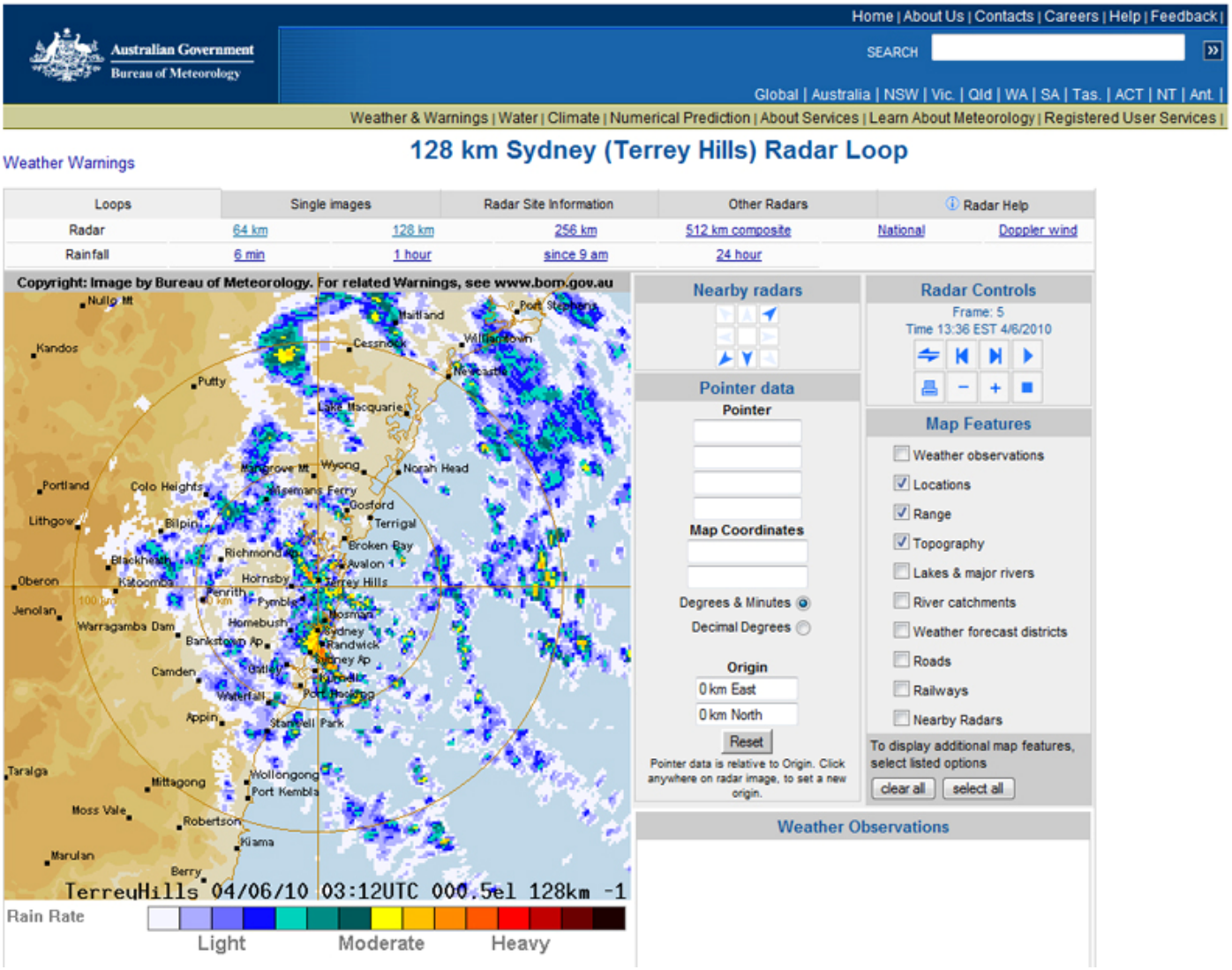
Radars

One of the marvels of modern technology and one of our most useful weather forecasting tools is the colour weather Radar. Radar stands for **RA**dio **D**etection **A**nd **R**anging, and as the name implies, is based on the use of radio waves. Radars send out electromagnetic waves similar to a mobile phone or wireless computers. These short pulses are then reflected by objects in their path back to the radar detector. The radar can detect rainfall, **but not cloud**, as the water droplets are too small. These areas of rain 'seen' by the radar are called Radar Echoes.

The Radar may sometimes detect echoes from Aircraft, areas of smoke/ash from large fires, swarms of insects, flocks of birds and even ground or sea surfaces. When unusual atmospheric conditions bend the Radar beam back down to the surface, the resultant image on the Radar may not be a true representation of the falling rain patterns.

A colour weather radar is available to you on the internet sites (BOM, Weatherzone etc). You simply choose your local area and the radar will be displayed (e.g. Figure 1). You can choose the static or loop option. The loop will show you in which direction the rain is heading and at what speed. In the loop option to get an idea of the speed of the rain bands or storms you simply place the pointer at the front of the approaching rain and click your mouse. This will reset the pointer data to zero, you then move the pointer on the front of the approaching cloud once again on the last loop. The pointer data will the give the distance covered by the approaching rain in the last 30 minutes. You can then use this same method to measure how long the rain band, shower or storm will last. However, if you want to know if your Drop Zone is covered in cloud see the satellite image section below.

Figure1: BOM Radar Loop



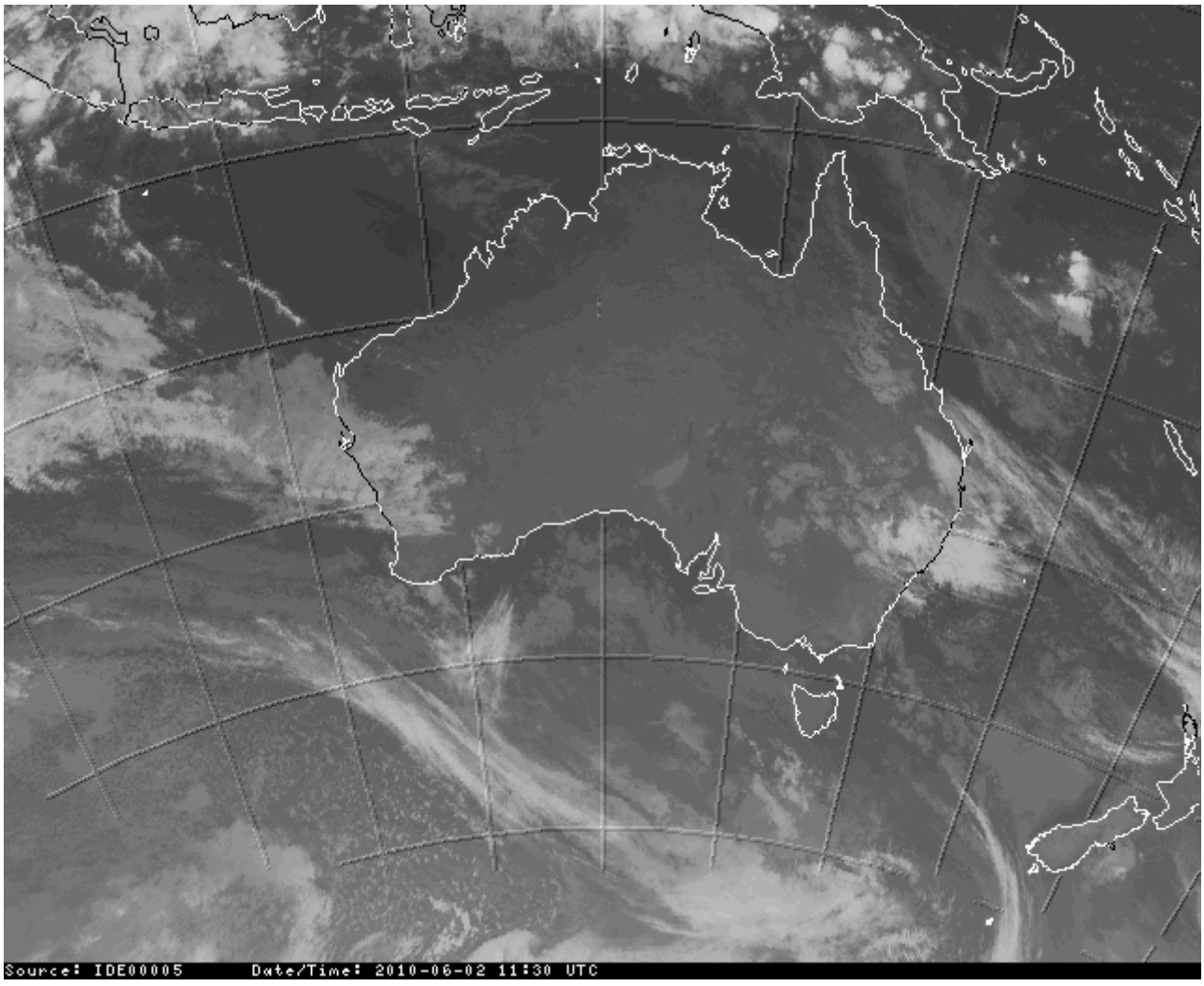
Satellite Images

Another vital tool to weather forecasting is Satellite imagery. The Australian Bureau of Meteorology (BOM) receives images from the Japanese Geostationary Meteorological Satellite operating in a consistent orbit 36,500km over the equator as well as images from U.S and European satellites.

There are two main types of images available on the BOM website. Infrared (IR) images, and Visible (Vis) images. IR images are derived from radiation (heat) emitted from the earth and it’s atmosphere. IR images are available 24 hours a day as the satellite is constantly reading temperature. The temperature readings are represented by a grey scale. Blackened areas represent no cloud and increasing white means there are higher colder clouds.

Visible images are displayed in a similar fashion to the IR images, however the images may only be viewed for the daylight hours as the Visible images are like a photographic snapshot of the present cloud. The information that these visible images provide enhances and complements the knowledge that the meteorologist has gained from the IR images.

Figure 2: Infrared image



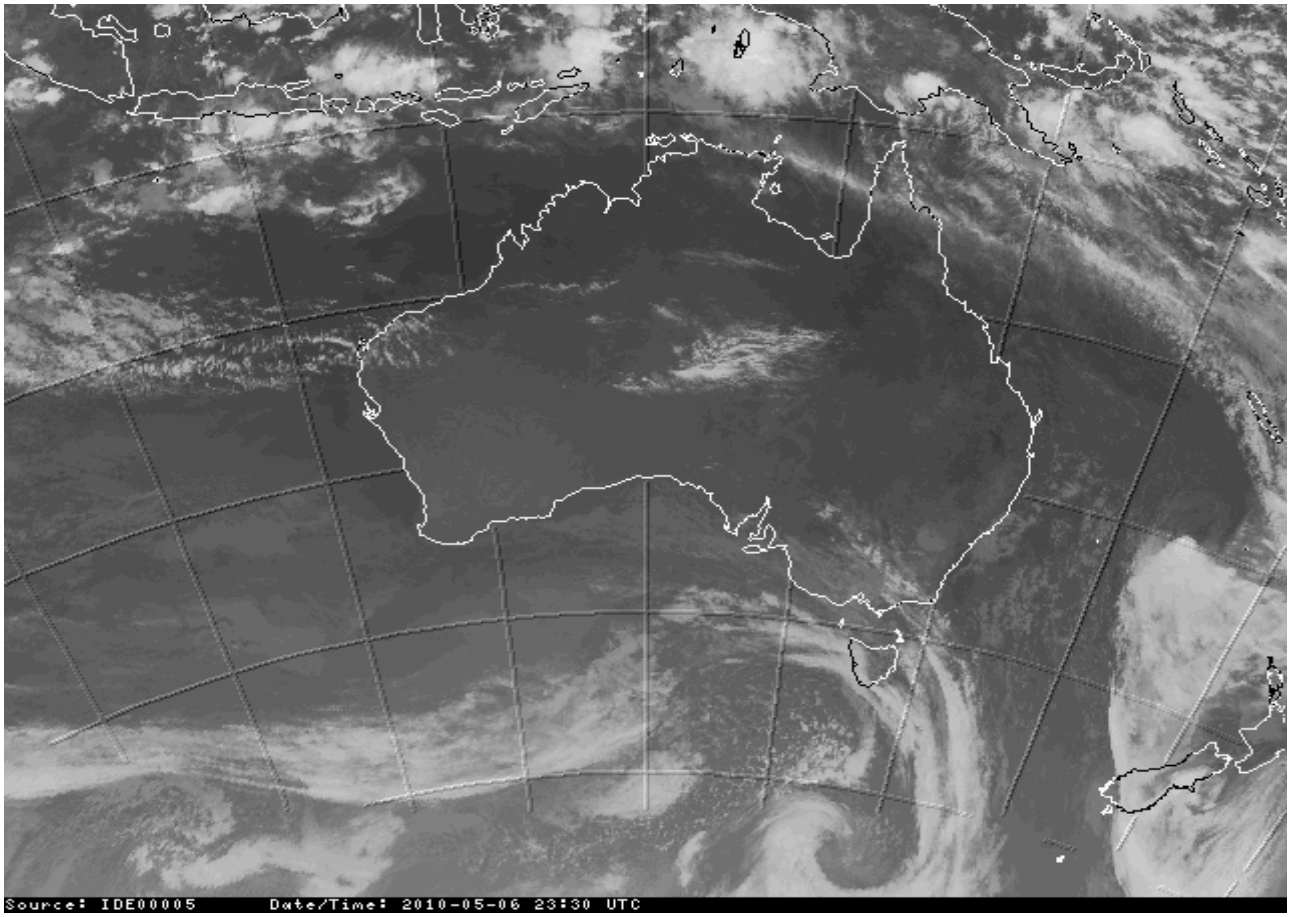
Using the black and white scale, with different shades of grey indicate levels of reflectivity.

- The brightest and most reflective surfaces are in white tones
- The least reflective surfaces are in black.
- In general, clouds are seen as white objects against the darker background of the earth’s surface.

The two images (Figure 2 & 3) complement each other. The visible image tells you whether there is cloud over the drop zone and the infrared will indicate if the cloud is high or low

For example; Fog appears in Vis images (Figure 3) but not on an IR image (Figure 2).

Figure 3: Visible Image



Synoptic Charts

You read a synoptic chart to gather information about the wind and ensuing weather conditions.

Most Synoptic Charts (Weather Maps) show isobars, being either a High or Low pressure system. The isobars, or lines, show areas of equal air pressure. On most maps they are marked with a number, which represents the air pressure in Hectopascals.

In a High-pressure system, the air pressure increases towards the centre, whereas in a Low, it decreases toward the centre.

Close spacing of isobars indicates strong winds, which are associated, although not exclusively, with Low-pressure systems. Conversely, where the bars are far apart, relative calm prevails. This weather is usually associated with High-pressure systems (which often produce clear skies). In winter, Highs can lead to low temperatures at night and, in both winter and summer, they often create stagnant conditions that cause pollution levels to soar.

It helps to understand how winds are flowing around the main highs and lows on a map and whether they are drawing in air from lower or higher latitudes. The weather patterns in the Southern Hemisphere move from West to East.

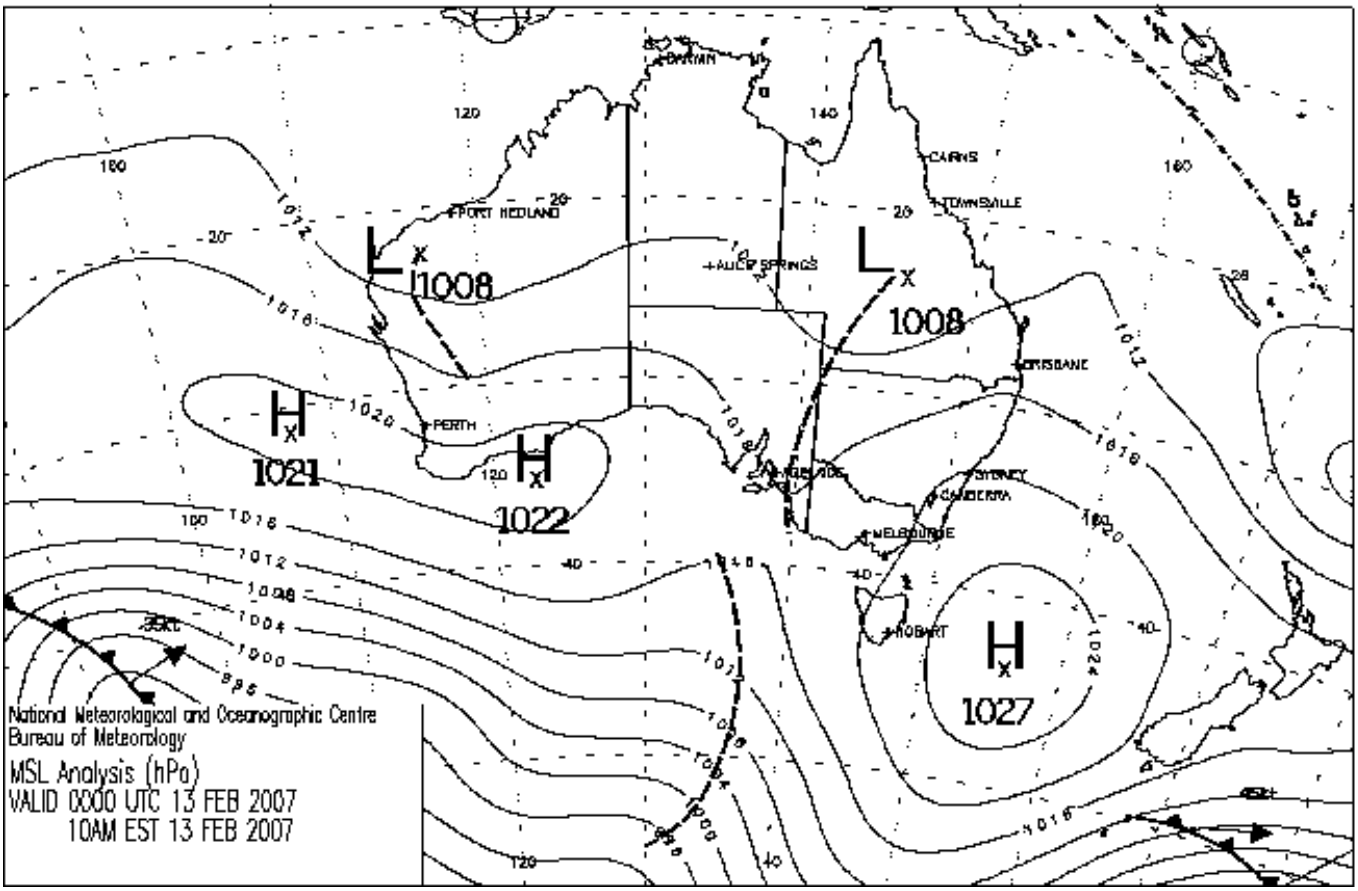
In the Southern hemisphere, winds flow in a clockwise direction in a low pressure system, and anticlockwise in a high pressure system (Easily remembered by c**L**ockwise = **L**ow). By following the isobars out from the centre of the pressure system you will be able to work out the direction that the winds are coming from, no matter which part of the country that you happen to be in. For example; the following synoptic chart (figure 4) shows that Easterly winds are expected in Brisbane, and Northerly winds are expected in Hobart.

The source of the wind will have a major influence on the type of weather that it brings. This is why the coldest spells in Australia occur when air from the Southern Ocean and Antarctica are thrown at the Continent. Wind generally flows from the poles towards the equator, and from the equator towards the poles. As the polar wind heads towards the equator it picks up heat and moisture. When this air mass hits the equatorial winds that are heading to the pole it produces an enormous energy source which fuels the often intense weather that is found in these latitudes.

Synoptic Weather maps also show fronts, which mark the boundary between air masses of different temperatures. The lines with triangles represent cold fronts, while lines with spheres show warm fronts. Cold Fronts are generally associated with low-pressure systems. Cold fronts tend to produce more volatile weather than warm fronts. When a cold front moves into an area of warm air, the warm air, being less dense, is forced sharply upward by the cold air, creating instability and powerful convection. Large cumulonimbus clouds may form, triggering storms along the front of the system. This creates an area of low pressure, which strengthens the winds. Rainfall will be heaviest and winds strongest along the front, but showers will also follow as clouds form in its wake.

Alternatively a Warm Front will not produce the highly volatile systems which are associated with the Cold Front. The meeting of the warm dense air (the Warm Front) with that of the cooler air will often be associated with widespread steady rain rather than the intense vertical motions associated with the Cold Front.

Figure 4: Synoptic Weather Chart

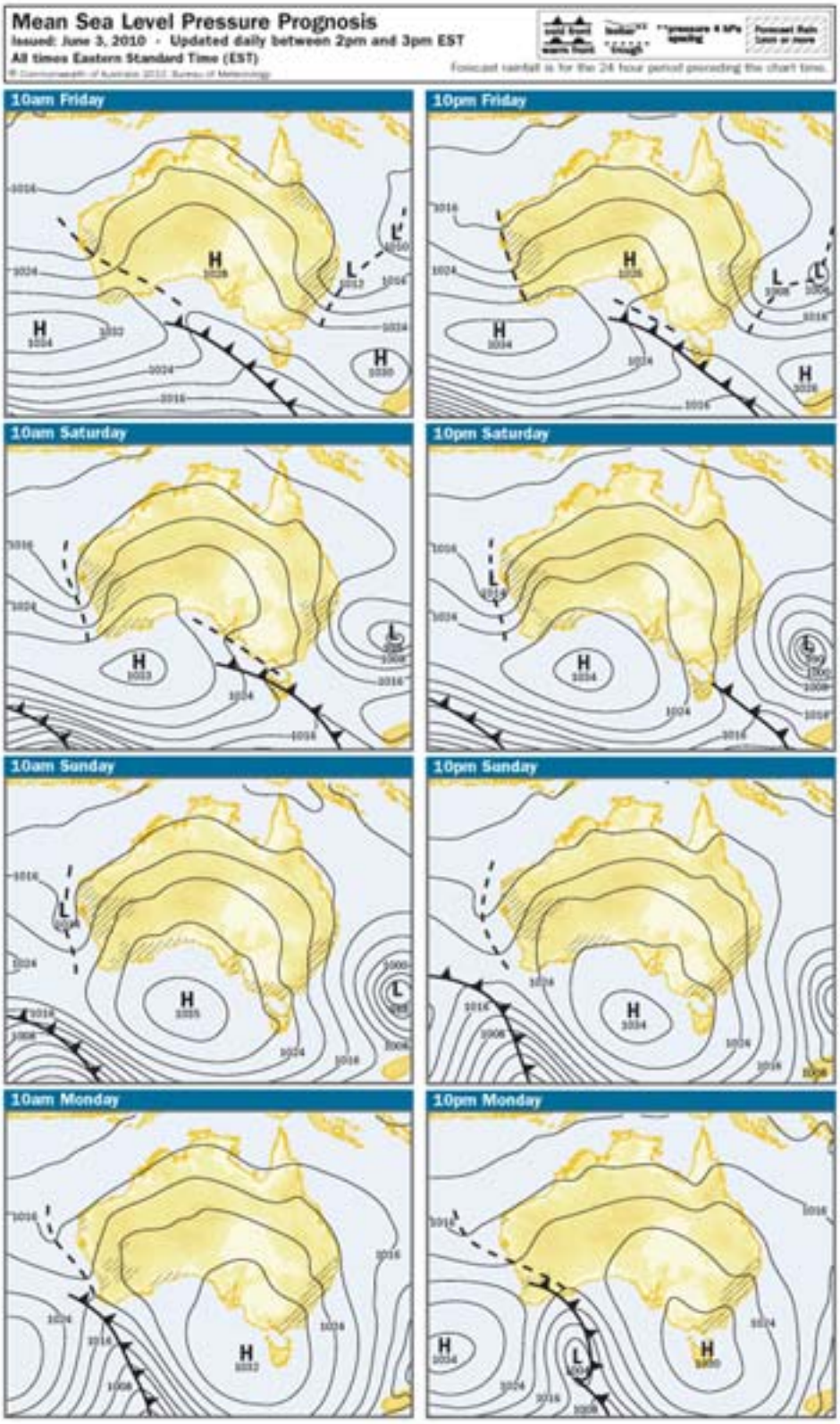


Once you learn how to read a Synoptic Chart you will find forecasts more informative. Look for the major features to determine what winds you might expect. You may then make your own informed decision about what type of weather you might expect in the next few days.

For instance, by reading the Synoptic Chart, one could interpret the following weather conditions:
Cairns: Clear skies, light and variable winds.
Brisbane: Fine, light easterly winds.
Sydney: Fine, light to moderate easterly wind.
Melbourne: Scattered cloud, light to moderate northerly winds.
Adelaide: Unstable weather, possible thunderstorms and moderate northerly winds.
Perth: Scattered cloud, light to moderate south-easterly winds.
Darwin: Fine, light and variable winds.

The following Synoptic Prognosis weather charts (Figure 5) can give you an indication as to the expected weather conditions you may experience over the coming days.

Figure 5: Synoptic Weather Charts Prognosis



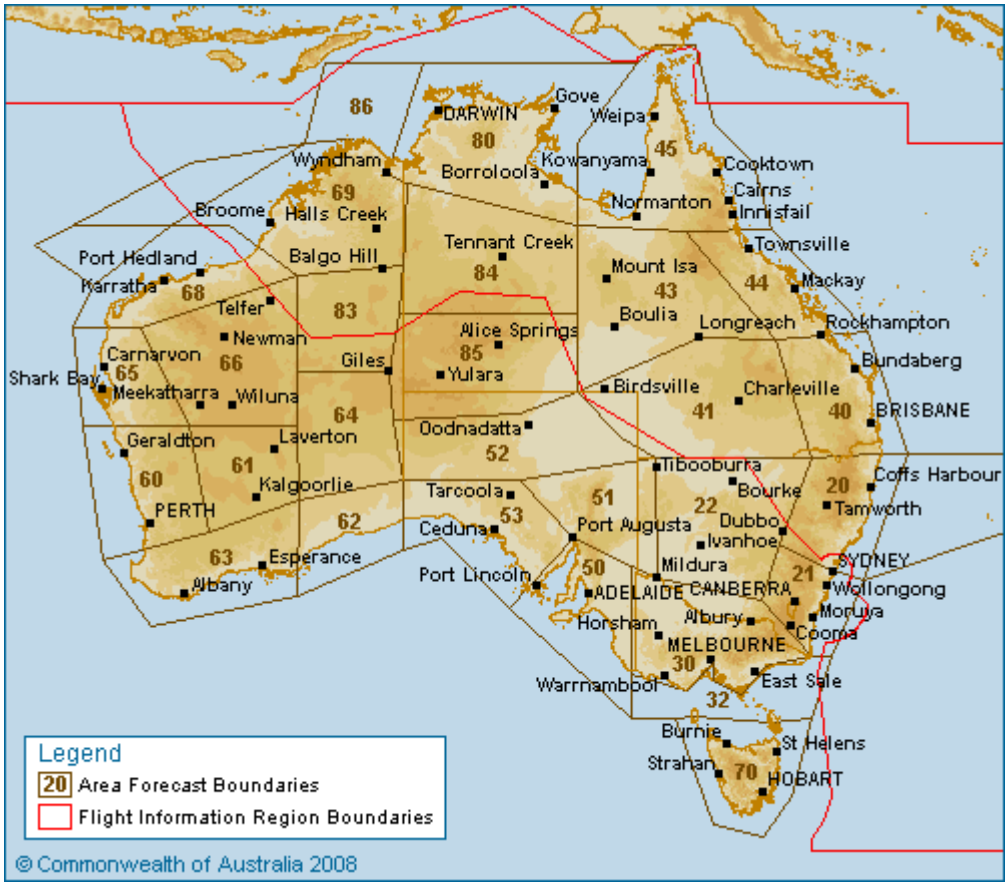
Aviation Area Forecast

Area forecasts

Aviation forecast can be very useful to skydivers and may be currently used at your DZ already. Area Forecasts (ARFOR's) can easily be obtained from the BOM website or from the Air services site. ARFOR's are primarily designed to meet the needs of pilots in General Aviation. In order to obtain an area forecast you need to register with an aircraft rego number and obtain a password. Most pilots can assist you with this. The system provides for the routine issue of a forecast for a designated area (Figure 6) and the prompt issue of amendments to the forecast.

While these forecasts cover large areas, they will still provide us with a good indication as to what to expect in regards to upper winds, cloud height and any forecasts of rain. It is important to remember that the figures that they provide need to be cross referenced with other tools mentioned in this manual as well as checked by the pilot against GPS readings during the climb to height in the plane.

Figure 6:



AREA FORECASTS FOR OPERATIONS AT OR BELOW 10 000 FEET

The Area Forecast system is designed primarily to meet the needs of pilots of general aviation. There is an emphasis on plain language and brevity in a simple, easy to read format. The system provides for the routine issue of forecasts for designated areas (see figure 5) and the prompt issue of amendments to forecasts

More detail of the area forecast boundaries with place locations is contained in the Airservices Australia, Planning

Chart Australia (PCA) available from the Airservices website. Your local pilot will be able to inform you on which area your DZ is in.

There may be variations in commencement of validity between different regions, and between those times when daylight saving is or is not operating. However the following principles apply.

- An area forecast will generally be valid for a period of time between 9 and 15 hours
- An area forecast covering **daylight hours will be available as soon as it its practical in the morning**
- Area forecasts will be prepared except for those times when air traffic volume is so low as not to justify routine issues. In these cases a route forecast will service any individual flight
- Area forecasts are generally published one hour before they are valid, except for Western Australia, where they will be available two hours before.

Figure 7:

AMEND AREA FORECAST 071700 TO 080500 AREA 21

OVERVIEW:
LOW CLOUD, DRIZZLE AND SCATTERED FOG W OF MVI/YSCB/YCOM TILL 03Z. ISOLATED REMAINDER TILL 01Z

SUBDIVISIONS:
A: W OF MVI/YSCB/YCOM
B: REMAINDER

WIND:

2000	5000	70000	100000	14000	18500
280/15	290/15	280/10	3000/15 MS03	300/20 MS09	300/25 MS20

AMD CLOUD:
A: BKN ST 2000/5000 TILL 03Z BKN CU 3000/7000 ISO L TOPS TO 13000
B: SCT CU 2500/5000 COAST, INCREASING TO 5000/7000 AFTER 02Z

AMD WEATHER:
A: DZ, FOG TILL O3Z
B: FG TILL 01Z

VISIBILITY:
3000M IN DZ, 500M IN FOG

FREEZING LEVEL:
5000FT

ICING:
MOD IN LARGE CU 5000/13000 FT

TURBULENCE
MOD IN LARGE CU.

CRITICAL LOCATION (HEIGHTS ABOVE MSL):
MOUNT VICTORIA: BKN ST 3700 (CLOUD ON GROUND)
BOWRAL 999 SCT SC 5000

REMARKS:
FOR CLARIFICATION OF METEROLOICAL ISSUES CALL 029296 1527

Identifier (AMEND AREA FORECAST in Figure 7)

The forecast is identified as AREA FORECAST unless the forecast is an amendment in which case it will be denoted AMEND AREA FORECAST. In the case of amended area forecast, all individual sections that are amended will be annotated with AMD preceding the section heading.

Period of Validity (071700 TO 080500)

The validity period is written DDHHMM TO DDHHMM, where DD is the day of the month and HHMM is the time in hours and minutes UTC.

UTC is an abbreviation for Coordinated Universal Time and is sometimes abbreviated to Zulu time or simply Z. It is the worldwide standard for time and date, and is based on an atomic clock. Previously it was known as standard Greenwich Mean Time (GMT). Eastern States of Australia are UTC +10. The Central States of South Australia and the Northern Territory is UTC + 9.5, finally Western Australia is UTC + 8 Hours.

For example:
03Z equates to 03 + 10 = 13:00 hours i.e. 1pm if you are on the East Coast or 11am if you live in Western Australia.

Area Number (AREA 21)

The relevant forecast area is specified by an area forecast district number. (See Figure 6) These are given in more detail on the current Air services Australia's Planning Chart Australia. Note that Areas 24, 87 and 88 are only designated for the purpose of Area QNH. Any flights in these areas will be provided with a route forecast.

The Overview

The overview will highlight any conditions which may inhibit safe operations for pilots flying under visual flight rules, and will make reference, where necessary, to any spatial and temporal variations. It will assist the pilot in making the following types of decisions. Are the meteorological conditions…..

- Visual Meteorological Conditions (VMC)?
- Marginal?
- Instrument Flight Rules (IFR)? or
- Too poor for flying?
- Is it better to plan for a coastal or inland track?
- If bad weather is encountered, what is the contingency plan? Return? Change altitude? Change heading? Land immediately?

The overview will refer to synoptic features or general stream flow when this will assist in defining the areas where safe operations may be jeopardized.

Subdivisions

Area forecasts may be divided into spatial, temporal or weather-related subdivisions.

Winds and Temperatures

Upper level winds are given for 2000 (or 3000 for elevated regions), 5000, 7000, 10 000, 14 000 and 18 500ft.

The expected mean wind direction is given in three figures to the nearest ten degrees - True, followed by the mean wind speed in two figures to the nearest five knots.

Example: 2000 = 15 knot breeze from the West / Northwest at 2000 feet
280/15

CALM and VRB05 (wind direction variable at 5 knots) are used when appropriate.

A REMARKS section may be included below the WIND section to provide further information on winds.

Upper level temperatures are given for 10 000, 14 000 and 18 500 feet. These are given in whole degrees Celsius, following the forecast of the upper wind for the level concerned. E.g. 290/40 PS08, 300/50 ZERO, 360/10 MS10.

Cloud

The following principles apply:
Cloud types are given using the abbreviations CU (Cumulus), SC (Stratocumulus), CB (Cumulonimbus), TCU (towering cumulus), ST (Stratus), AS (Altostratus), AC (Altocumulus) and NS (Nimbostratus).
The inclusion of cloud is restricted to:

- any CB or TCU.
- any cloud at or below 5000 feet above the highest terrain in the area concerned by the forecast.
- any cloud layer of more than 4/8 base (broken or overcast) at or below 20 000 feet above MSL.
- any cloud associated with any forecast precipitation, moderate or severe icing and moderate or severe turbulence.

If subdivisions are used and one or more subdivisions have no cloud associated with it, the format used is, for example, A: NIL CLOUD.

Cloud amount is given as:

- SCT - (scattered - 1 to 4 oktas);
- BKN - (broken - 5 to 7 oktas) or
- OVC - (overcast - 8 oktas), except for CB and TCU which are described using;
- ISOL - (isolated) for individual clouds;
- OCNL - (occasional) for well-separated clouds;
- FRQ - (frequent) for clouds little or no separation;
- EMBD - (embedded) is added to other abbreviations to indicate CB and TCU clouds that are embedded in layers of other cloud; and
- CB is mentioned first, and then TCU, then cloud with the lowest base, then the next higher base, and so on in ascending cloud base height.

When CU and SC, or AC and AS, occur together at similar heights, they are combined, i.e. CU/SC or AC/AS. Cloud base and tops are given in feet above MSL.

Weather

Weather information relating to the layer below 21 000 feet above MSL is given following the word 'WEATHER'. If subdivisions are used and one or more subdivisions have no weather associated with it the format is, WEATHER A: NIL.

Visibility

Horizontal visibility is given in metres to the nearest 100 metres up to and including 5000 metres, and in whole kilometers above that value. Forecast visibilities of 50 metres or less are given as 'ZERO'. The forecast value is followed by the units used e.g. '8KM' or '1000M'. Significant variations of visibility are included. If the visibility is forecast to be above 10 kilometres throughout the area, the words 'UNRESTRICTED' or 'GOOD' are used. Vertical variations of horizontal visibility, which might prevent flight under VMC conditions, are significant. For example, information is supplied on the depth of layers affected by drizzle, haze and dust storms, and the levels of haze layers under inversions. A visibility variation with these phenomena is given.

Freezing Level

Freezing level is the height, in feet, above MSL of zero degrees Celsius. Reference is made to any variations in height greater than 1000 feet, and to the occurrence of more than one freezing level.

Icing

Icing section gives information on the expected occurrence of moderate or severe icing in cloud (including convective cloud), or precipitation, in the layer below 20 000 feet above MSL.

The height above MSL of the bottom and top of the layer is given as, for example, MOD IN RA 5000/8000.
When the layer of icing is expected to extend above 20 000 feet, descriptions such as MOD ABOVE 14000 are used.

Turbulence

This section provides information on moderate or severe turbulence including turbulence associated with Convective cloud.

The height above MSL of the bottom and top of any layer(s) is given as, for example, MOD IN CLOUD 12000/16000

When the turbulence is expected to extend to ground level, descriptions such as BELOW 8000 are used.
When the turbulence is expected to be confined to clouds, descriptions such as MOD IN CLOUD BELOW 8000 are used.
When the turbulence is expected to extend above 20 000 feet, descriptions such as SEV ABOVE 15000 are used.

Critical Localities

These are locations such as gaps in mountain ranges which are frequently used by general aviation aircraft. Currently, critical location forecasts are appended to Area Forecasts for Bowral and Mt Victoria (NSW) on AREA 21; Mt Victoria and Murrurundi (NSW) on AREA 20; and Kilmore Gap (Vic) on AREA 30.

Critical location forecasts are written in a mixture of plain language and TAF format making reference as necessary to cloud, visibility and weather.

Remarks

This section will include any relevant information not included elsewhere in the forecast. There are a number of abbreviations used in the Area Forecast for a full explanation please see Appendix 1.

Internet Forecasts

The BOM site provides the most useful forecasts available and is where Television Radio and newspapers get most of their information that they then pass onto the general public. With this in mind, why not cut out the middle man and go straight to the source of the information. There is a variety of forecasts, observation and warnings that are the direct information that we require as skydivers. We have looked at the area forecasts now let's take a look at general forecasts. (See Figure 8, 9 and 10)

Figure 8: Land Forecast

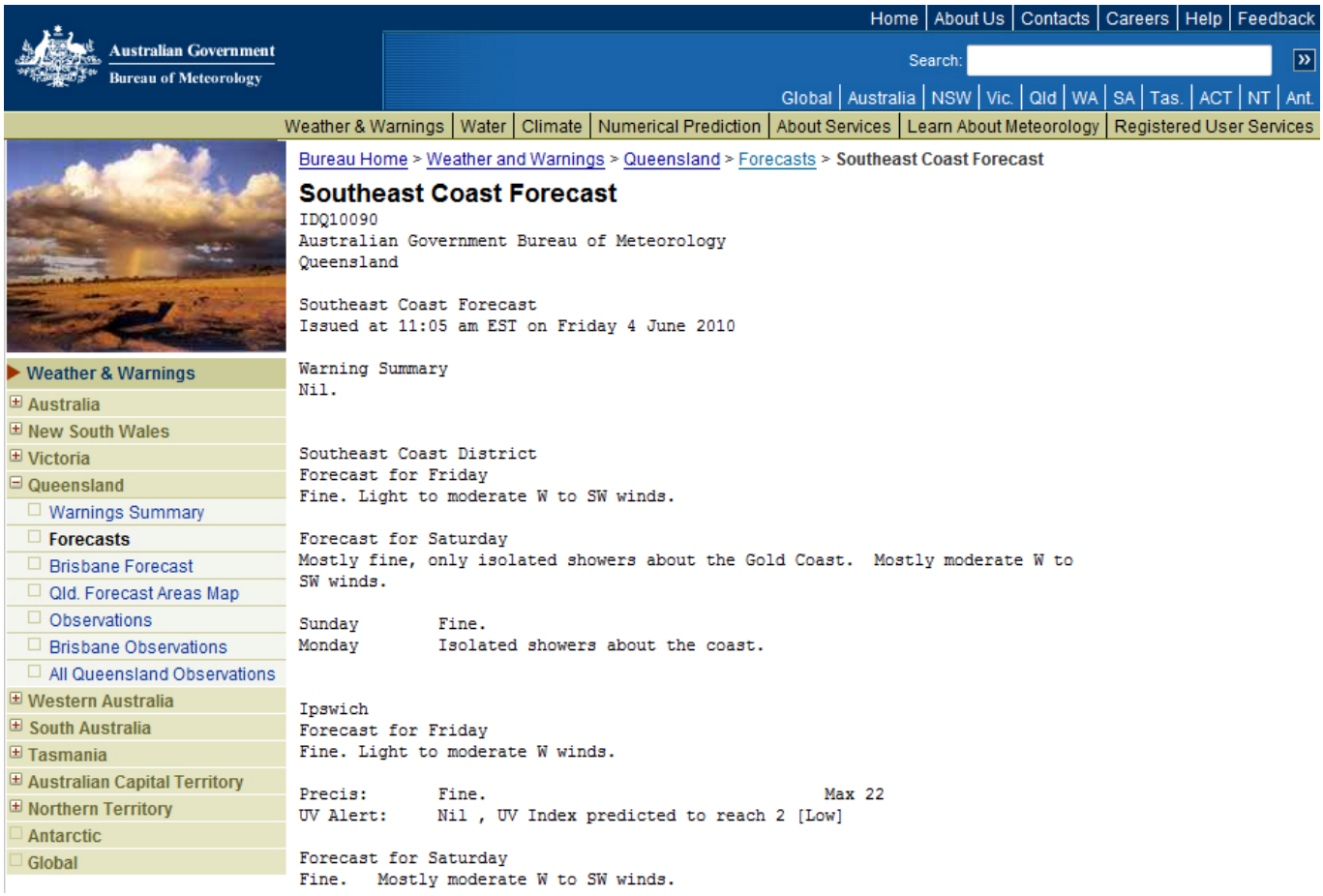


Figure 9: Coastal Waters Forecast

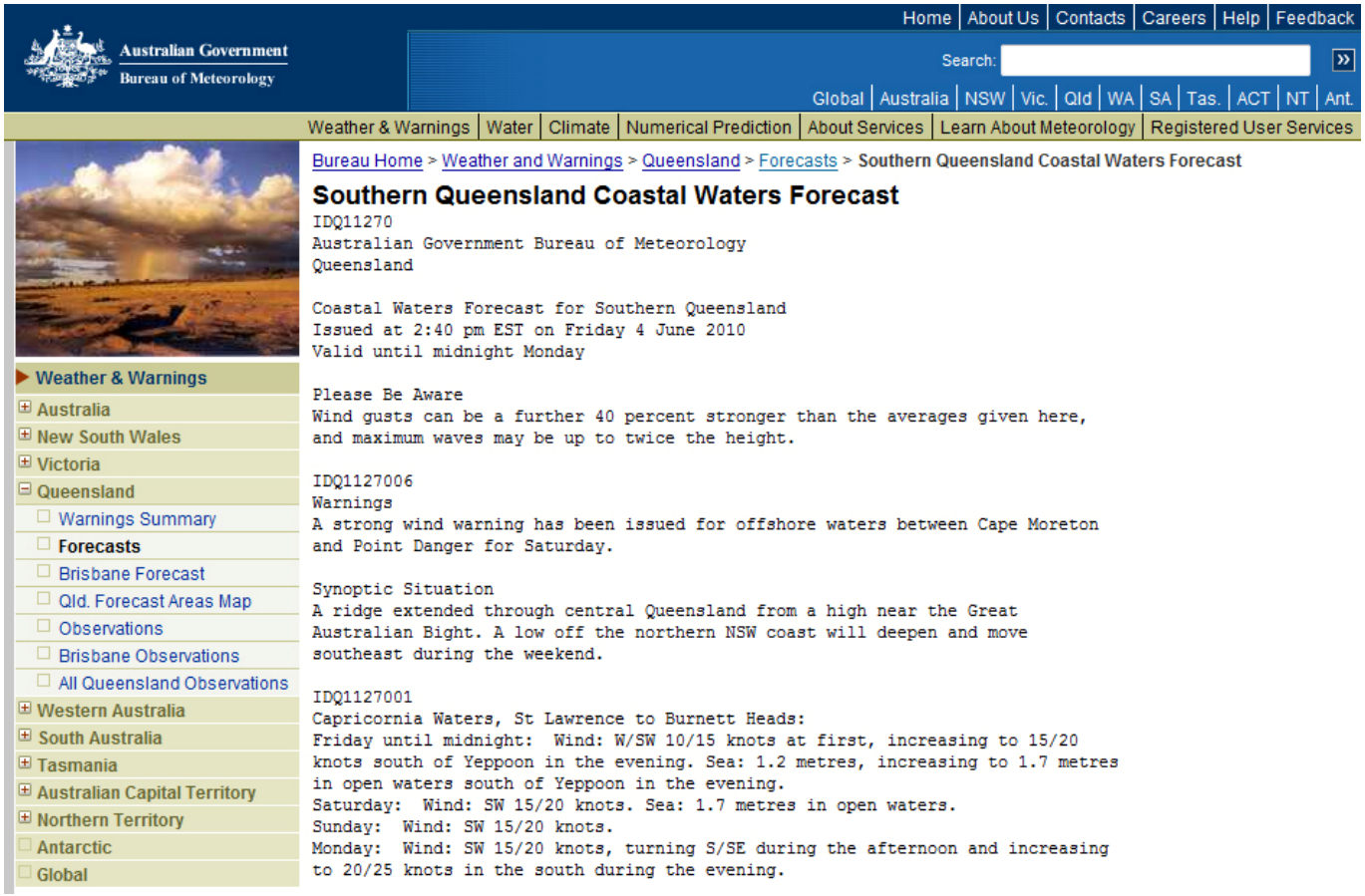
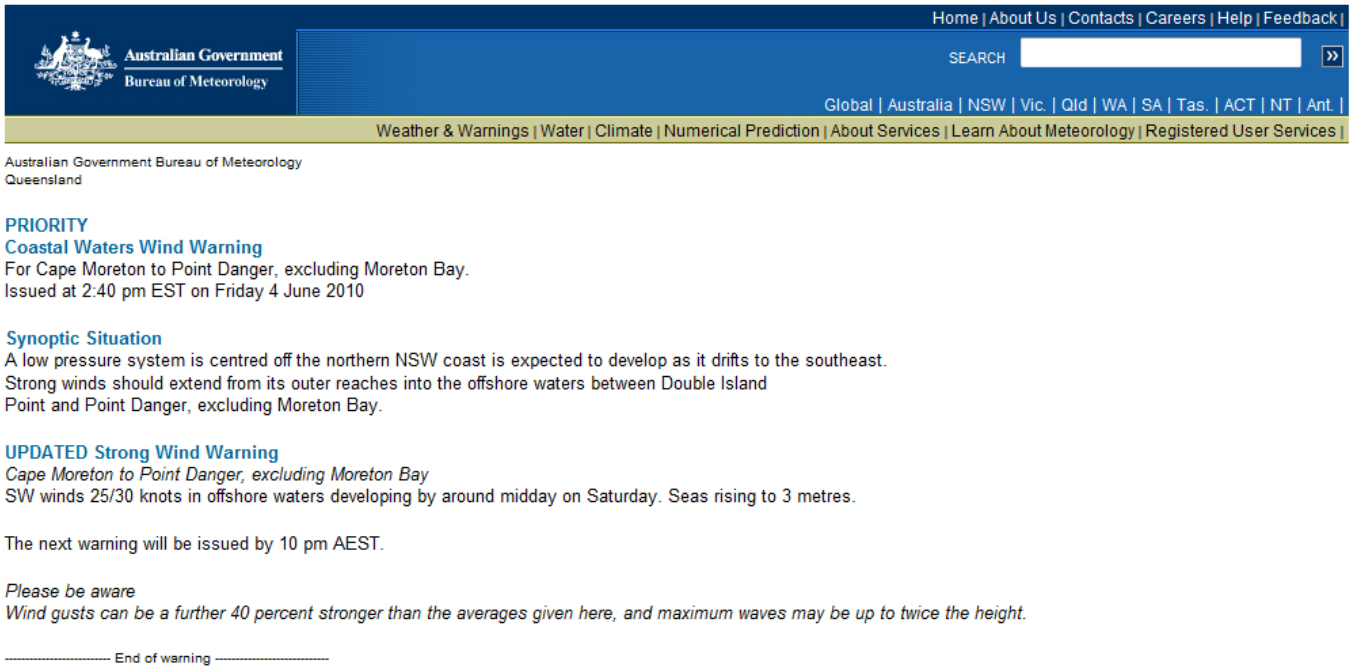


Figure 10: Weather Warnings



The Land Forecast (Figure 8) will provide you with a general idea of the coming conditions with an indication of the wind strengths and directions along with rainfall and temperature guides.

The Coastal Waters Forecast (Figure 9) is ideal for coastal Drop Zones and will give you far more accurate indications of wind direction and speed. These forecasts do not generally apply to inland Drop Zones.

The Weather Warnings feature of the BOM website (Figure 10) provides localized severe weather warnings including storms, hail, flooding and strong or gale force winds. Figure 10 shows a strong wind warning for an extended coastal area between Double Island Point and Point Danger.

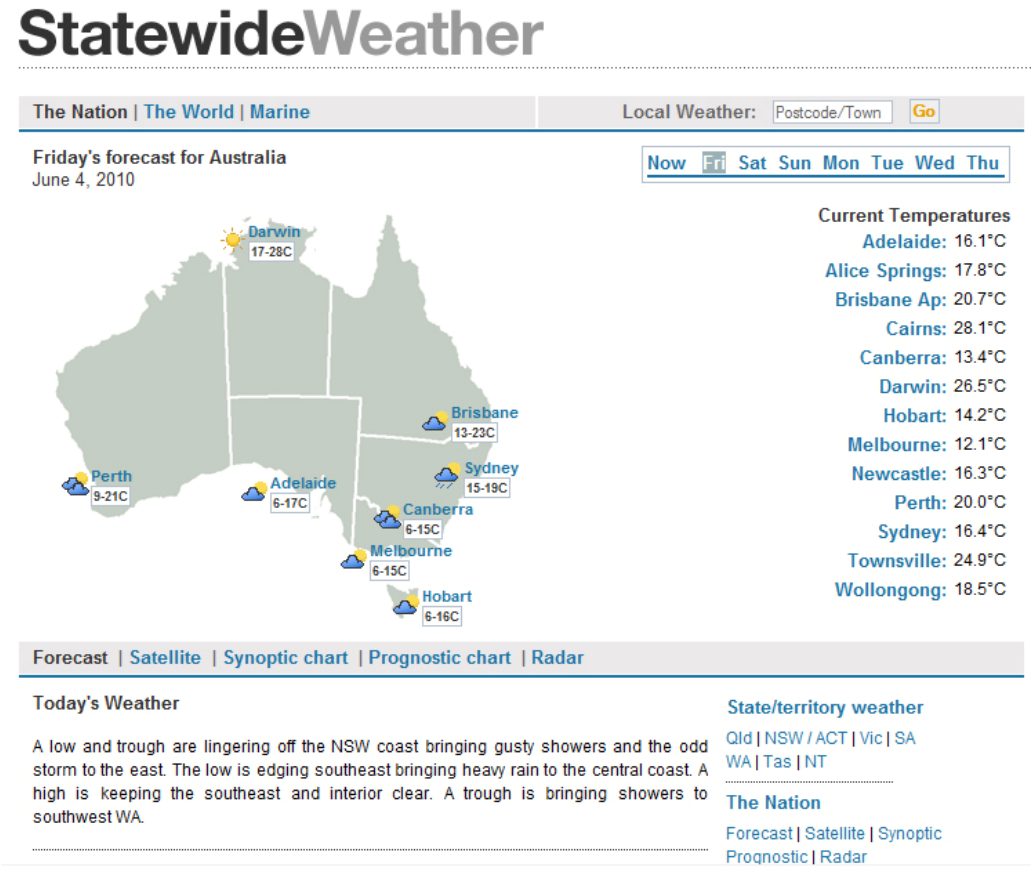
Skydivers and Drop Zone operators would do well to take heed of these warning to avoid any unexpected weather issues that my severely interrupt operations and or cause injury or death.

Television & Publications

Provides probably the easiest to digest information, as the info is presented in layman's terms. However be very wary of the week-long forecasts. The only accurate forecasts are valid for approximately two days. Seven-day forecasts are solely based on trends and what history has shown us in the past. The weather is an incredibly complicated system and will never be totally predictable.

Newspapers are useful for brief summaries in layman's terms. They will also show synoptic charts and cloud maps. (Figure 11). While these publications will give you basic indication as to what we might see weather wise in the coming days, they are only a basic guide to what the weather may have in store for us. As you can see in figure 11, the newspaper weather guide is not something that will give you the detailed information that you may require.

Figure 11:



What information is available at my DZ?

Windsocks and Anemometers

The wind reading tools available to you at a drop zone will vary from place to place. If you never ask you will never know. Many drop zones have an anemometer that measure wind speed, some will also tell you which direction the wind is coming from. There are many different size windsocks that indicate different speeds. The larger windsocks are generally aircraft windsocks and are rated to 25 knots (Figure 12). This means that when they are inflated and horizontal the wind speed is 25 knots. When they are approx. half way to horizontal then the speed may be closer to 12 knots (Figure 12).

Streamer poles and wind blades are useful for indicating the direction of the wind though they may not give you a true indication of its speed. They do tend to flick more when it is stronger, though this may not always be easy to see. Hopefully your DZ may have a combination of wind indicators across the DZ so they you may make a more informed decision of exactly what the wind indicators are telling you.

It is important to note the physical location of the windsock. That way you will have an easier time spotting it from the air. Hopefully it has been placed in an open area and is not affected by turbulence in any way. Be very wary if the windsock is in the Lee (downwind) side of an object, as the windsock will then be giving you the wrong impression about what the wind is doing when it is prevailing from upwind of the object.

Figure 12: Typical Licenced Aerodrome Windsock

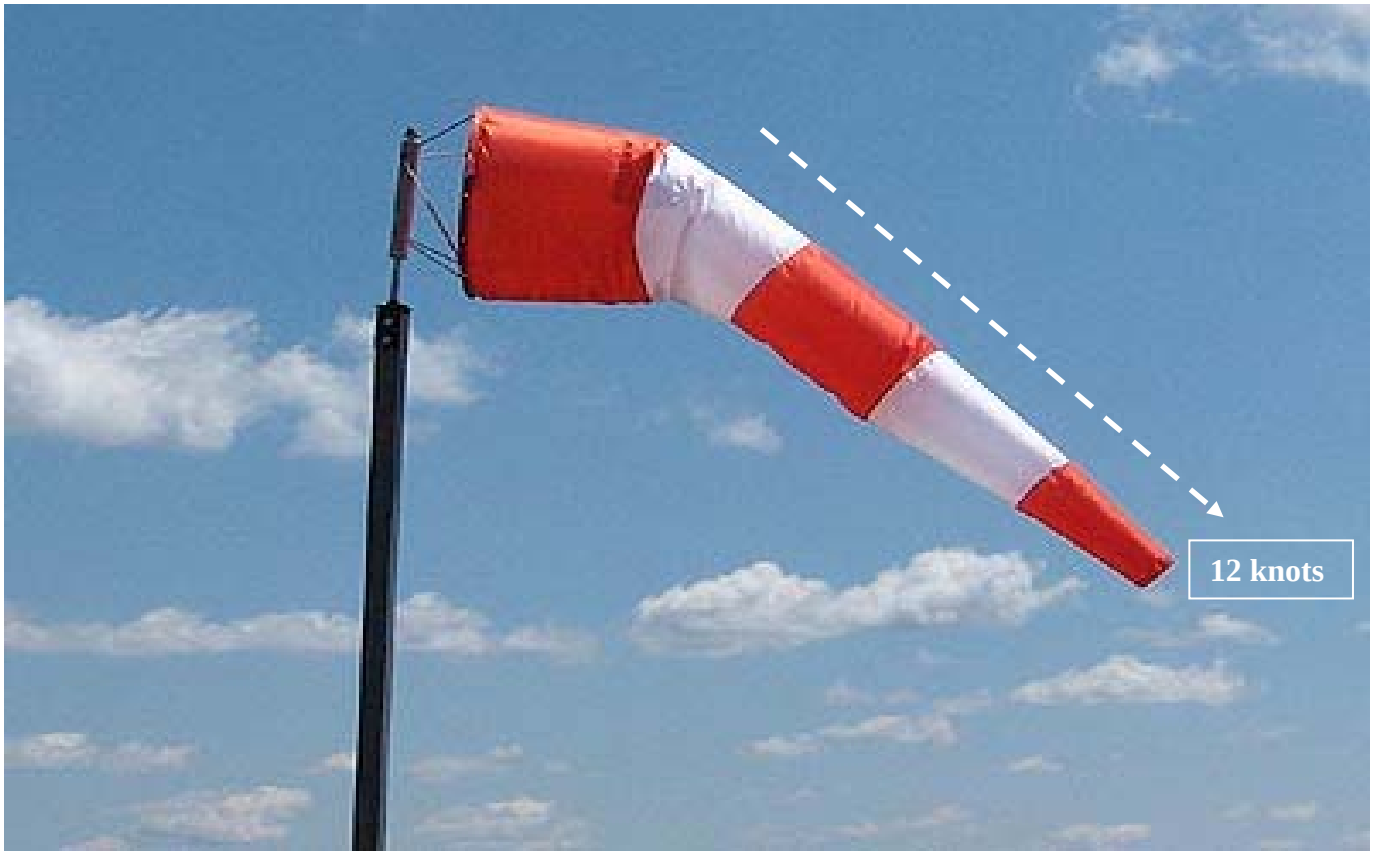


Figure 13: Anemometers

Add 25% to your Wind Reading on the Ground.

If the windsock or anemometer is not positioned so that it is 30 feet (9 metres) above the ground, then you need to add 25% extra to the wind strength that you are observing. As the wind that is closer to the ground moves across it, friction of the wind on the earth cause the air to move slower. Therefore to get a true indication of the speed of the wind, simply add 25% to your estimation using the windsock or anemometer.

Operational Regulations
15 May 2010

PART 9-PARACHUTING LIMITATIONS: WEATHER

9.1 Cloud and Visibility

Except where Descents are made in accordance with the written specifications of CASA or a delegate of CASA, all Descents must be made in meteorological conditions that:
(a) Permit the Target to be clearly visible throughout the Descent; and
(b) Do not require the Parachutist to enter cloud.

9.2 Wind Speed

(a) For all Descents, except night Descents and display Descents, the wind speed must not exceed the following limits or any lower limit determined by the DZSO:

(i) Student Parachutists:	15 knots
(ii) Parachutists holding a Certificate "A" or "B":	20 knots
(iii) Parachutists other than Student Parachutists and not using ram-air main and reserve parachutes:	20 knots
(iv) Parachutists holding at least a Certificate "C" and using ram-air main and reserve parachutes:	25 knots

(b) Wind speed should be measured at a height of nine (9) metres above the DZ but where measured at eye level the wind speed must be recorded as the actual reading plus twenty-five (25) per cent.

(c) Wind speed should remain below the specified limits for at least ten (10) minutes before commencing or resuming Operations.

Note: Wind speeds for night Descents can be found at 11.2.3 (c) and wind speeds for display Descents can be found at 12.1.7.

How can I determine wind strength and direction without the use of windsocks?

Depending upon where your DZ is located there may be many varied methods of determining wind strength and direction. Some of the indicators may take some time to get accustomed to making an informed decision on what the strength is. The indictors include;

Fires and Smoke - There may be fire in the area or more regularly an industrial factory that produces smoke on a regular basis. This will typically indicate direction more than speed. However, if the smoke is horizontal and continues to be for some time, then you could happily assume that it is very windy. If the smoke is rising at an angle then you know that the speed is considerably less.

Dust - In rural areas, it is not unusual to see tractors encircling paddocks and kicking up a lot of dirt and dust. Similar to smoke, this will indicate direction though it may take some time before you can use it accurately to judge its speed.

Trees - This indicator typically will give you a better impression of speed rather than direction. Trees tend to sway, which makes it harder to judge direction. If you are on the ground a rather large Gum tree looks like it is waving to you, then you should stay on the ground and wave back at it.

Long Grass - Tends to be a good indicator of direction, though not speed. Remember to look at the grass as if it were a windsock. The top of the grass is doing what the tip or tail of the windsock is showing you.

Water - Larger dams or rivers are good indicators of wind. Sometimes you may see surface swell (ripples) as a result of the wind. Be wary of rivers that are surrounded by high banks and may be sheltered from the true wind. However these high-banked rivers or dams can also show wind direction and strength if you are observing the “wind shadow”. A wind shadow, as can be seen in Figure 14, is the lighter coloured water closer to the river bank. This will show the water on the Lee side (the downwind side) of a bank will appear to be smoother than the wind that is directly exposed to the wind. The horizontal dimension of the shadow will tell you the strength of the wind, with a longer shadow indicating a higher wind speed. If your DZ is close to the ocean, then it is important to know that white caps typically start appearing at around 12-15 knots.

Figure 14: Wind Shadows

Figure 15: Water lines

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• **When direction is shifting;** this usually indicates a frontal system is approaching and that there will be a pressure change (e.g. An increasing sea breeze or oncoming thunderstorm).

• **Steady winds typically show little change in present weather**, but they can also be an indicator to approaching rain (depending upon the direction and barometric pressure trend).

• **Decreasing winds** usually suggests current conditions will continue.

• **Wind speeds increase** typically during daylight hours and decrease at sunset.

• **A Nighttime OR sunrise wind** that is steady or increasing typically means weather is soon going to change drastically

Local Knowledge:
It has been said that if you want to know what the weather is going to do, then you should go and ask a local. While weather forecasters have tens of millions of dollars worth of equipment and are dealing with an area in Australia of over 50 million square Kilometres, it is impossible for them to forecast every one of those kilometres accurately.

This is where ‘local knowledge’ comes into play. A nearby mountain range can have effects that may not show on a weather map, though it may have a dramatic effect on the local weather patterns. For example, the direction of prevailing winds, the average time that the sea breeze kicks in or the frequency and duration of thunderstorms.

Local knowledge can be invaluable to a new or visiting skydiver on the DZ. Simple things such as where the turbulence may be. While we may know in theory where to find it, by having a chat with the locals we can be reminded and guided to the best landing area for the particular conditions of the day.

While a DZ briefing from the CI or DZSO will help inform us of what we need to know, they may not be long term locals. So while you are on a weather hold, go and chat to a local. They may be just the right person to give you the local weather tip you have been looking for.

If you are in doubt as to where the wind indicators are or how they may help you make an informed decision then simply ask your DZSO to help you. Alternative, Pilots spend many years studying and watching the weather. Pilots, particularly if they are local, will be a good source of weather prediction and or information.

GPS

One of the marvels of modern technology is the introduction of the Global Positioning System or GPS. By reading satellites it can determine your position anywhere on the planet with an accuracy of a few metres. Many modern GPS also have a feature which can also work out the winds aloft. By entering the heading and airspeed of the aircraft the GPS can work out the wind speed and direction at that given height. If the GPS that is being used does not have this feature then you can still get a fairly accurate indication of the wind by having the pilot carryout a slow orbit and then comparing the airspeed (from the ASI) to the groundspeed (from the GPS). The heading at which the Groundspeed is the lowest is the direction that the wind is coming from. The difference in speed between the Airspeed and the Groundspeed is indicative but not absolute thanks to the inaccuracy of the ASI due to the pressure differentiation caused by altitude.

Figure 16: Garmin GPS Hand-held

Signs in the Sky - Watching the Cloud types, shadows and movement:

We all spend a considerable amount of time looking towards the sky, wishing we could up there. By becoming more familiar with cloud types and their movement, you will also be able to make educated guesses about developing weather conditions.

Most of us are aware that dark threatening cloud mass may mean that a rain storm is developing and a steady decline in the number of clouds may mean that conditions are improving. However, if you learn the types of clouds and their relative altitudes you will be able to make a more informed decision about what type of conditions to expect.

The three main types of cloud to recognise are high-level, mid-level, and low-level clouds. High-level clouds, such as cirrus or alto-cumulus, may indicate an approaching frontal system. When low-level clouds, such as stratus, move in behind middle- and high-level clouds, rain may be on its way.

Cumulus clouds form vertically, and may extend from low to high-levels. Fair-weather Cumulus clouds (cumulus humilis) usually indicate continuing settled weather. At the opposite extreme, cumulus clouds growing in size over the course of a few hours indicate instability and the threat of thunderstorms that may bring fierce, gusty winds, strong up-drafts, and heavy rain and/or hail.

In the middle latitudes (Wikipedia states; The **middle latitudes** are between 23°26'22" North and 66°33'39" North, and between 23°26'22" South and 66°33'39" South latitude) weather generally moves from west to east, though local winds may be influenced by other factors. For instance, in coastal regions, sea breezes may blow in a completely different direction from winds that are being experienced a few miles inland. If a large thunderstorm approached, it draws air into it, so the surface wind may blow toward the storm in the opposite direction to the storm’s movement.

By observing the wind and monitoring a barometer (your altimeter) you can sometimes get an idea of the approaching weather. In the middle latitudes of Australia, falling air pressure (your altimeter reads higher than zero on the ground) accompanied by increasing wind from the southwest can indicate the approach of a frontal system (a Low Pressure System).

A clouds movement is a good indicator of what the winds are doing a loft. Remember that the wind speed and direction at various heights can be completely different to what is happening on the ground. It is important to take note whilst climbing to height as this will aid when spotting. When you are on the ground you can determine the wind by comparing the cloud movement with a fixed object, i.e. a Hangar roof, tree etc. Also take note of the clouds shadows when you are on your ride to altitude, the speed and movement of the shadow will inform you of the wind speed and direction.

Figure 17: Cloud Shadows along the surface of the ground

How the information will affect your jumping

Having the raw data is only the beginning of the journey to making a weather decision. You now need to be able to interpret the information to give you a true insight into the weather and then use this insight to be able to extract the information to allow you to make an informed and educated decision.

The Effects of Changing Altitude

As skydivers, in the aircraft we aim to climb as quickly and efficiently as possible, and of course once we step out the door we descend quicker than most aviators would ever imagine.

At an altitude of 16 500 feet (5000m) air pressure is half the value that it is at sea level and so there is only half as much Oxygen available. At 13 000ft (4000m) it is reduced by 12% and at 6 500ft (2000m) it is reduced by 4%.

The combination of these effects means that people breathe more rapidly, increasing the amount of Oxygen in the blood but reducing the Carbon Dioxide. This can lead to irregular breathing, headaches, and faintness, which are all symptoms among many others of hypoxia. The onset of Hypoxia may cause you to make irrational decisions or even black-out.

The sunburning power increases by 4% every 1,000ft in altitude. At an altitude of 10 000 ft there is 50% more UV radiation in sunlight than there is at Sea Level. This is because most of the gases and dust that absorb UV radiation occur below 10,000ft.

Lapse Rate: Wikipedia defines the lapse rate as the rate of decrease with height for an atmospheric variable. For every 1,000ft of altitude the temperature reduces by 1-2 degrees.

So we do put ourselves through extremes of many environmental factors. By learning more about your environment you can only help yourself and others deal effectively with its extremes.

Cloud types

- There is no point gearing up for a jump if the DZ and surrounding area is covered with low thick cloud;
- It’s important to be able to understand / know at what heights the various cloud types sit and at what height their cloud bases are with reference to your opening heights; and
- Just because it’s overcast doesn’t mean you can’t go jumping.

Turbulence / wind / heat

- The air, like the ocean is rarely still;
- It is important to understand areas affected by turbulence on your DZ or when arriving on a new DZ;
- Mechanical turbulence is caused by obstacles on the ground eg. Buildings, trees etc. It can reach quite high in the form of a mountain wave. Where the wind is passing over a mountain range close

to the DZ. The stronger the winds the more turbulence will occur and the area affected will be greater; and

- Convection turbulence is generated from heat hence the name convection. Convection turbulence is caused by rising pockets of warm air, and it can reach quite substantial altitudes. This turbulence includes "Willy-willies, or Dust-devils" These are small intense low pressure systems which can be up to 400feet high and in some instances be invisible.

Storms

- You only have to talk to someone whose been caught in a storm whilst skydiving to understand the dangers involved with these powerful weather systems; and
- The simple rule of thunder storms is, **"don't go near them"**. Even in their infant stage they can be quite powerful. Strong winds, hail, and heavy rain, are not the conditions we want to go skydiving in, simply stay away from them!

Spotting

One of the dying arts in our sport is that of spotting the aircraft. This is usually determined by the DZSO, and with the assistance of a GPS the pilot flies the desired heading to the exit point. The direction of the jump run and the distance from the landing area that you exit the aircraft is important in determining whether you will "make it back" or have a long walk home.

Cloud manuals

Some Drop Zones, though not all, have a Cloud Manual. The Cloud Manual is an official document created by the DZO, which outlines the DZ's procedures for the safe operation of jumping in cloudy conditions. The following points are important to note:

- In order for you to legally jump thru cloud your DZ must first have an approved cloud manual. Having said this, just because your DZ has a cloud manual doesn't mean that it's automatically ok for you to jump in cloudy conditions; and
- Cloud base, cloud tops and thickness are all important considerations. This can be determined in a lot of cases simply by looking at the clouds and determining the types of cloud that you're looking at.

Legal limits

The legal wind limit for students is 15 knots, jumpers who do not have a "C" Licence are limited to 20 knots, and 25 knots for experienced jumpers. All of these limits are at the discretion of the DZSO who may impose a lower limit due to a number of factors such as wind direction, obstacles, currency of skydivers, size of parachutes flown etc. This is once again where the local knowledge side of things kicks in, Just because it's within the legal limits doesn't mean you should automatically gear up.

Safety

The physical location of the DZ will affect the types of weather in which the Operation may run. If the DZ is located near a large body of water (such as beach, or near a large lake), or near a mountain range where the height of the

mountains may constitute a danger to the opening heights of parachutes, then the limitation imposed on the cloud manual will be higher. You would not like to jump into cloud if there was a 3000’ mountain hiding somewhere in it!

Types of jumping

CRW, FS, Classic Accuracy, and swoop accuracy all will be affected by different types of wind and weather. The DZO will plan for differing levels of both wind, and cloud cover based on what type of jumping is occurring on the DZ at the time.

When to say NO

Knowing your own limits is an important skill in skydiving. If you feel like the conditions aren’t suitable for your skill level, or that you cannot handle the conditions you may be confronted with simply say NO!

Checklist of things to look at once you have arrived on the DZ

Talk to the DZSO / Pilot.

- The DZSO should be happy to inform you about the current weather conditions. They should know the current Area Forecast. If so, they will be able to tell you about the winds at various levels and whether such conditions are meant to improve or deteriorate throughout the day; and
- Quite often the DZSO will publish the known current winds on a notice board either around manifest or the emplaning area.

Once you have more experience, you may be able to read and interpret the Area Forecast before you arrive or check the current forecast once you are at the DZ

Check the Anemometer (Wind Metre) and the windsocks. You may need to spend 10-15 mins observing the wind and the trends that are displayed. During that time you might be able to watch a load descend under canopy and give you a better idea of the current conditions.

- Is the wind consistently at the same speed?;
- Is the wind showing significant signs of gusts?;
- Is the direction of the wind remaining fairly consistent or is it continually changing?;
- Is the wind increasing/decreasing during the 10-15min intervals?; and
- Are the wind gusts (if any) becoming more frequent or less frequent?

Observe the clouds, *if any*.

- How quickly does the layer of cloud appear to be moving? Which direction does the wind seem to be moving?;
- Are there multiple layers? Are they moving in different directions to each other?; and
- If there are no clouds Then refer to area forecasts and GPS winds aloft feature.

Talk to fellow jumpers and Pilots.

- They will be able to give you a first-hand account of what the conditions are like, if they have been up recently. They should be able to tell you if the air is stable and smooth or unstable and turbulent;
- Talk to various people of differing experience levels:
    - Someone of low experience might tell you that conditions are fine, though only because they are naive to the conditions. So be cautious taking their advice;
    - A Higher experienced jumper will give you a more informed opinion in what conditions are like. If you see a lot of advanced pilots, sitting on the ground and not jumping, then it is for good reason. Take the hint and join them; and
    - Pilots need to complete study in the subject of Meteorology to be able to attain their Pilot’s Licence, so most have a good knowledge of, at least, the basics of Meteorology.

Conclusion

It is essentially up to you to decide whether the conditions are right for you to jump. Only you truly know your ability and skill level. You need to get the information required to make a good decision as to whether to jump or not, so it makes sense to be familiar with the weather systems which affect your jumping.

The weather is truly an amazing (almost living) feature of the planet, and one which should not be taken lightly. The more we understand the weather, the more we can work with it to ensure that the outcomes of our activities are not going to be put at risk. Skydiving is very weather dependant, high risk activity and as such, as part of our risk management an understanding of it should be promoted.

This Thesis will point you in the right direction to be more in charge of your own choices once you arrive at the DZ, and should help to ensure that you are never put into a situation where there is unacceptable risks taken with the weather.

About the Author

Archie Jamieson started skydiving in April 1986, at the Golden Beach Skydiving Centre, Byron Bay. To this date, Archie has completed more than 12,000 descents and holds an Instructor B with Static Line, Accelerated Freefall and Tandem Endorsements. He is actively involved in Skydiving Full time, running his own operation ‘Gold Coast Skydive’ located on Kirra Beach in South East Queensland.

Archie spent many years skydiving around various Drop Zones in the South East Queensland are. After first obtaining his Instructor D static line rating in 1987, Archie furthered his instructing career path by obtaining his Tandem master rating and AFF endorsements in 1993 and Instructor B in 1994. Along with instructing, competition skydiving was also, very much part of Archie’s skydiving experience. At the 1987/88 Nationals, his team, R.E.M won silver in the intermediate four-way formation skydiving event. In 1993, Archie captained his team ‘*Paradox*’, to a nationals win and continued on to represent Australia at the 1994 World Canopy Formations Championships at Kooralbyn. In doing so setting a new Australian record in CRW (rotations) that was to stand for many years to come. Over the years, Archie has been involved in, and organised many skydiving displays and obtained his License Display Organiser (LDO) in 1995.

From November 1994 -98, Archie held the position of General Manager at the Byron Bay Skydiving Centre. During which time was co-organiser of the highly successful ‘Boogie on the Beach’ 1, 2, and 3. In April 1999, Archie took up the position as Operations Manager of Paul’s Parachuting. Since then, Archie has participated in the 81 way Australian Record in Corowa, 1999. Archie and his team, ‘Hairspeed’, won gold at the 2000/01 Nationals, again setting a new record and going on to represent Australia for a second time at the World Air Games in Spain, 2001

From 2001 to 2004, Archie worked at Taupo Tandem Skydive in New Zealand as a full time Tandem Master, AFF Instructor and Camera Flyer.

He returned to Australia in 2005 and began work at the Gold Coast Skydive Centre, of which he is now the owner/operator. Archie has also been very involved with Learning Curve Camps in Toogoolawah, helping skydivers of all levels advance their skills.

Since 2005, Archie has completed in Swoop and Canopy Formation Nationals and was a member of the successful 25 and 36 way Canopy Formation Record. With this wealth of experience, Archie has decided to write a manual ‘Meteorology for Skydivers’ as he believed that this is an area that is lacking in many skydivers general Knowledge.

Appendices

Appendix 1:

Abbreviations Used in Area Forecasts

ABBREVIATION DESCRIPTION

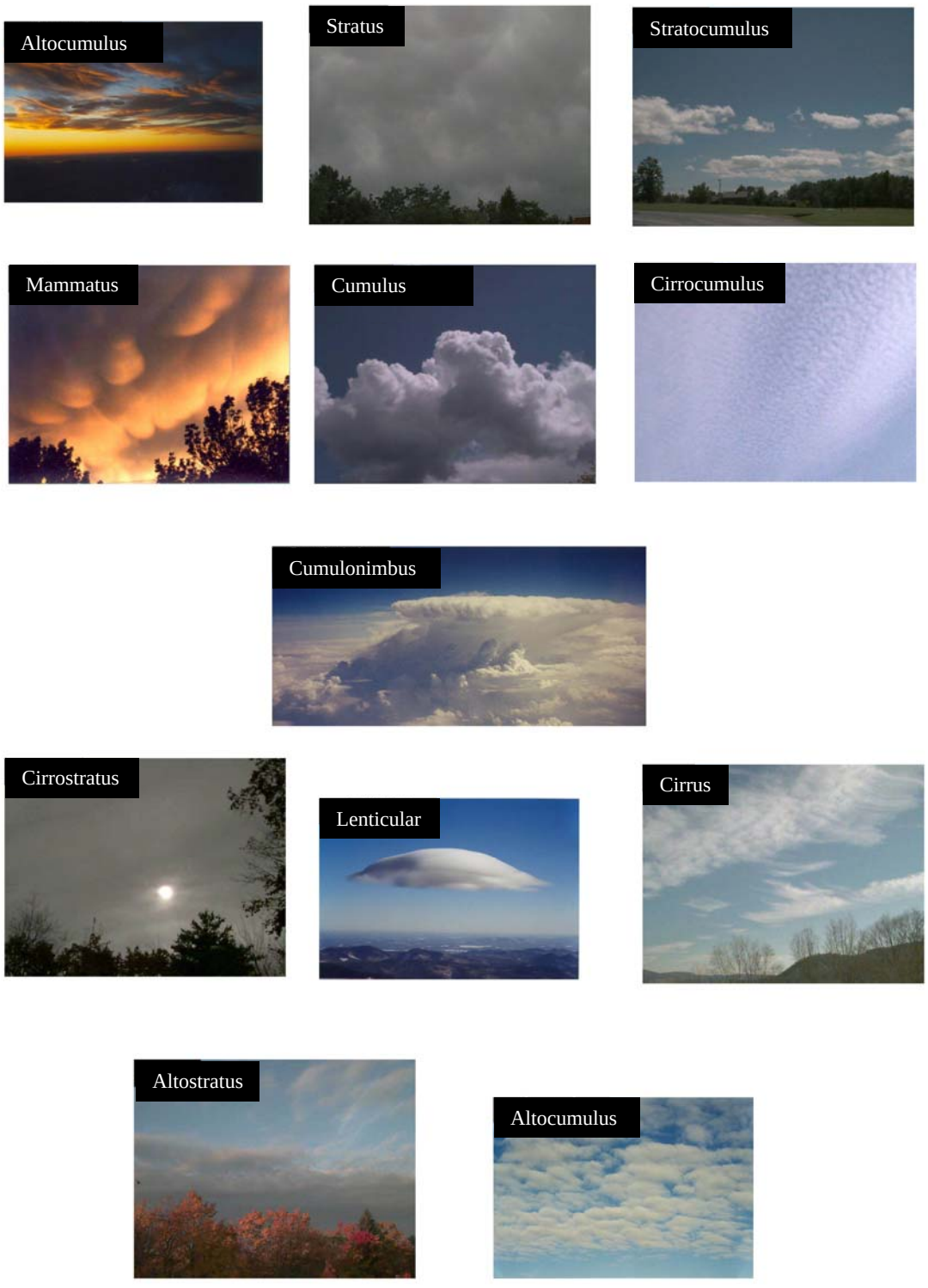
- CB - Cumulonimbus
- TCU - Towering Cumulus
- CU - Cumulus
- SC - Stratocumulus
- CU/SC - Cumulus and Stratocumulus with bases at the same level
- ST - Stratus
- AC - Altocumulus
- AS - Altostratus
- AC/AS - Altocumulus and Altostratus with bases at the same level
- NS - Nimbostratus
- TS - Thunderstorm. Refer here for decode of other weather
- FEW - Few
- SCT - Scattered
- BKN - Broken
- OVC - Overcast
- ISOL - Isolated
- OCNL - Occasional
- FRQ - Frequent
- EMBD - Embedded
- MOD - Moderate
- SEV - Severe
- Z - Code for UTC (international time)
- CAVOK - Cloud and visibility and weather ok.
- FM - From (only used in Critical Locations)
- TEMPO - Temporary variations (only used in Critical Locations)
- INTER - Intermittent variations (only used in Critical Locations)
- AMD - Amendment

Appendix 2: Clouds and their associated rain & ice

CLOUDS AND THEIR ASSOCIATED RAIN & ICE

HIGH	**Cirrus**	**Ci**	Cloud	Fine strands, hooks or clumps of cloud.
			Rain	No precipitation.
			Ice	Made of ice crystals – no icing.
	Cirrostratus	**Cs**	Cloud	Sheet of fine hairy, wispy or thread-like cloud.
			Rain	No precipitation.
			Ice	Made of ice crystals – no icing.
	Cirrocumulus	**Cc**	Cloud	Cirrus forming in elements or lumps.
			Rain	No precipitation.
			Ice	Made of ice crystals – **rare** icing.
20,000^{ft}				
MID	**Altostratus**	**As**	Cloud	Sheet of middle level cloud.
			Rain	May produce **rain** or **virga**.
			Ice	**Light rime ice** – **Clear ice** in thick As.
	Altocumulus	**Ac**	Cloud	Heaped or lumpy cloud in the middle level.
			Rain	Not usually associated with rain.
			Ice	Greater possibility of **rime ice**.
8,500^{ft}				
LOW	**Cumulus**	**Cu**	Cloud	Heaped or towering cloud.
			Rain	May produce **showers** of **rain** or **snow**.
			Ice	May produce **clear ice** in large Cu up to 5000^{ft} above FL – Rime **ice** above this.
	Cumulonimbus	**Cb**	Cloud	Towering thunderstorm cloud.
			Rain	Produces **heavy showers** of **rain**, **hail** or **snow**.
			Ice	**Clear ice** up to –15°^{C} above FL – **Rime ice** above this.
	Stratus	**St**	Cloud	Low sheet of cloud.
			Rain	May produce **drizzle**.
			Ice	**Light rime** ice if below 0°^{C}
	Stratocumulus	**Sc**	Cloud	Sheet of heaped or towering cloud.
			Rain	May produce **drizzle**.
			Ice	**Rime ice** if below 0°^{C}
	Nimbostratus *(orographic)*	**Ns**	Cloud	Sheet of heavy rain cloud.
			Rain	Produces **heavy continuous rain** or **snow**.
			Ice	**Clear ice** up to 5000^{ft} above FL – **Light rime ice** above this.

Appendix 3: Clouds Types



Examples of Various Cloud Types