

The Weather Map

The weather map is one of the most familiar images in the community. The best known map is the mean sea level analysis, compiled from hundreds of weather observations (synoptic data) taken simultaneously around the Australian region. It is seen daily on television and in the newspapers.

Its dominant features are the smooth, curving patterns of sea level isobars — lines of equal atmospheric pressure — which show the central elements of our weather systems: highs, lows (including tropical cyclones) and cold fronts. It incorporates the effects of atmospheric processes at higher levels.

Television and newspapers also often carry forecast weather maps which indicate how the weather patterns are expected to develop.

Meteorologists use a wide range of information and techniques to formulate weather forecasts. The weather map does not and cannot show all of these factors. It is a fairly simple representation of past and probable future locations of surface weather systems (highs, lows, fronts, etc.). Nevertheless it provides a useful guide to the weather.

Everyone benefits from a better understanding of the weather map, especially people whose activities are particularly weather-sensitive — pilots, farmers, mariners, builders, outdoor sports enthusiasts — who often find the maps valuable, sometimes essential, to enhance their understanding of media forecasts and help form their own ideas based on local experience.

Preparing the weather map

The weather map can be likened to a giant jigsaw puzzle, assembled several times a day (usually three-hourly) from thousands of observations taken at internationally agreed times. The Bureau of Meteorology, like all the world's Meteorological Services, operates a network of its own stations to gather surface and upper air observations. More than 440 paid and volunteer part-time observers also make daily surface observations essential to the national picture.

Surface reports usually comprise observations of mean sea level pressure, wind direction and speed, present and past weather, temperature, dew-point (a measure of atmospheric moisture), cloud and visibility. Their information is formatted in an international code and transmitted nationally, often globally. Complementary, if less detailed, surface data come from the Bureau's expanding system of more than 100 automatic weather stations, ship reports, and from drifting buoys in the surrounding oceans.

Specialist observers gather **upper air** information on wind speed and direction by radar-tracking weather balloons, which may also carry instrument packages to transmit temperature and dew-point information at various heights (pressures) in the atmosphere. Some aircraft transmit upper air data.

Weather satellite data are a vital part of the analysis process. Australian meteorologists focus on hourly images from the Japanese Geostationary Meteorological Satellite operating in geostationary orbit 36,500 kilometres over the equator. Computer enhancement adds colour for easier interpretation. The animated sequences often shown on television are a particularly powerful analysis tool.

The Bureau's National Meteorological Centre in Melbourne also draws on similarly enhanced images from USA and European geostationary satellites, as well as high-resolution images and atmospheric temperature profiles from polar-orbiting USA satellites.

Vast numbers of observations on national and global scale flow to the supercomputers at the Bureau's Melbourne headquarters. The computers' mathematical models (equations) simulate atmospheric processes to produce three-dimensional broadscale weather analyses and prognostic maps which form the basis of weather forecasts for up to four days ahead. The models simulate the physical processes that determine how the atmosphere reacts to constantly changing pressure, temperature and humidity.

Fine-scale surface weather maps are prepared manually in Bureau forecasting offices, particularly the Regional Forecasting Centres in each State capital and Darwin, and Meteorological Offices in Canberra and Townsville.

Meteorologists take account of the centrally produced computer surface and upper air predictions, local data and manual charts, and animated satellite and radar images when preparing forecasts and warnings.

What do weather maps show?

The most obvious features of the media's weather maps (Figure 1 is an example) are the

patterns of high and low pressure, and the barbed lines identifying cold fronts. In the southern hemisphere, the earth's rotation causes air to flow clockwise around low pressure systems and anticlockwise around high pressure systems. (The opposite applies in the northern hemisphere.) Friction over the earth's surface causes the winds to be deflected slightly inwards towards low pressure centres, and slightly outwards from high pressure systems. Wind strength is directly proportional to the distance between isobars — the closer the lines, the stronger the winds. This rule does not apply in the tropics where the effect of

the earth's rotation is weak. For this reason, tropical meteorologists usually replace isobars

with streamline arrows which indicate wind and direction without directly relating to the pressure gradient. Shaded areas on weather maps show where there has been rain in the previous 24 hours, and wind direction is shown with arrows that have a series of barbs on their tails to indicate speed.

The coverage on media weather charts is usually limited to the continent and surrounding oceans. The Bureau also produces global charts to take account of weather systems interacting with each other over great distances. Global charts are necessary when preparing forecasts up to four days ahead, and framing the monthly climate monitoring bulletins.

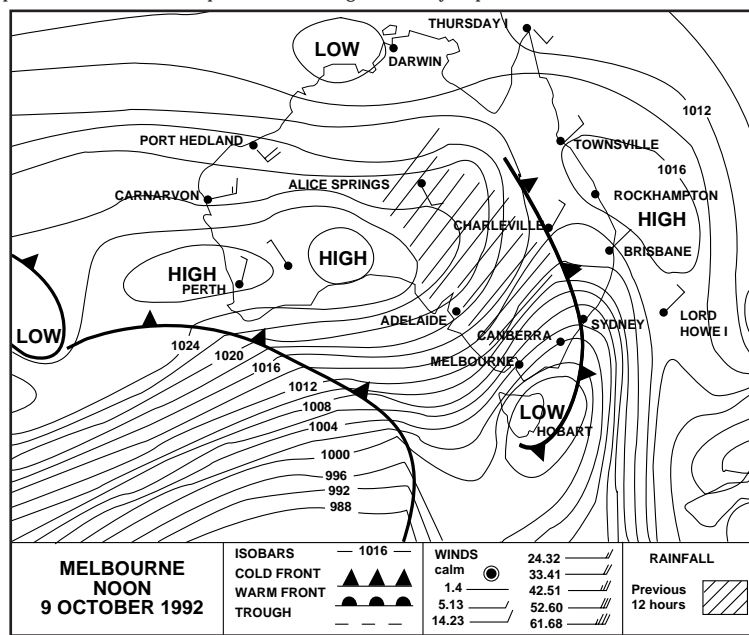


Figure 1 Typical newspaper weather map.

Typical weather map patterns

An understanding of some systematic weather patterns is needed when interpreting a map.

- **Easterly winds** over the tropics and subtropics incorporate wavelike disturbances which usually travel westward. Important features of the tropical easterlies include the southeast trade winds, monsoon lows and sometimes tropical cyclones (known as hurricanes in the Americas and typhoons in Asia).
- **A high pressure belt in the mid-latitudes** (usually 30-50 degrees latitude) contains centres of varying strengths which generally move from west to east. Fluctuations in the intensity of these highs ('anticyclones') strongly influence the behaviour of the trade winds and the development and decay of tropical lows.
- **The belt of westerly winds** south of the high pressure region contains disturbances

which usually travel from west to east. Barbed lines indicate the leading edge of travelling cold (and occasionally warm) fronts, the boundaries between different types of air. The term 'front' was applied during World War I by European meteorologists who saw similarities between atmospheric structures and the large-scale conflict along battle fronts.

- Nearer the pole, **a series of deep subpolar lows** is usually centred between latitudes 50-60 degrees South.
- **A high pressure area over Antarctica** — associated with extremely cold and dense air — is ringed by easterly winds which form the boundary with the subpolar low pressure belt.

These typical features vary in intensity and location according to the season. For instance, in summer the high pressure belt is usually found

just south of Australia, while the subtropical easterlies cover most of the continent. Monsoon flows and associated lows over the tropics bring significant summer rain; tropical cyclones may develop. In winter the high pressure belt is usually located over the continent, allowing westerlies and strong cold fronts to affect southern Australia.

It is important to be alert to significant exceptions to this 'normal' situation when, for example, strong high pressure systems move slowly across the oceans well south of Australia. Closed or 'cut off' lows may then move across southern Australia or intensify over the Tasman Sea, possibly causing prolonged heavy rain.

It is also important to remember that all weather systems have a life cycle of development, maturity and decay. They occasionally show unusual behaviour. They may become stationary or even briefly reverse their usual direction of travel.

Hot or cold?

Remembering that air flows clockwise around low pressure systems and anticlockwise around high pressure systems, a fairly typical summer weather map (Figure 2) shows:

- **Northerly winds over eastern Australia** on the western flank of a Tasman Sea high. They carry hot, dry air from inland Australia southward over Victoria and Tasmania. With winds strengthening ahead of an approaching front, this represents a classic weather situation with extreme bushfire risk.

- **Moist, easterly flow** from the Coral Sea onto the Queensland coast causes very warm, humid and sultry weather east of the Great Dividing Range. This air, often susceptible to the development of showers and thunderstorms, is described as 'unstable'.
- The **cold front** passing South Australia replaces the hot, dry northwesterlies with southerlies carrying cooler, often relatively humid air from waters south of the continent.

Such summer fronts are often quite shallow and may not penetrate far inland, particularly if they are distorted and slowed over the Victorian mountains.

In Figure 3, a relatively common winter weather map shows:

- **Very cold, unstable air** from well south of Tasmania flows northward over Tasmania, Victoria and southeast New South Wales, reducing normal day temperatures typically by

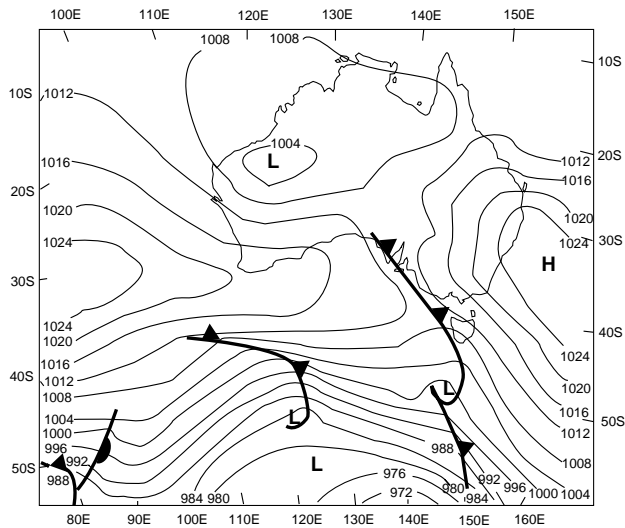


Figure 2 A summer weather map.

five degrees or more. Note the cold front, the deep low pressure (pressures below 976 hectopascals) south of Tasmania and the high (1020 hectopascals) south of the Bight. Occasionally, rapid interaction with other weather systems around the southern hemisphere can almost halt the pattern's eastward movement, causing successive cold fronts to

bring a prolonged spell of cold, showery weather to southern Australia.

- **Easterly winds** over inland Australia. Although southern cold fronts become shallow and diffuse as they move into northern Australia they often trigger a surge in the strength of the easterlies and this, combined

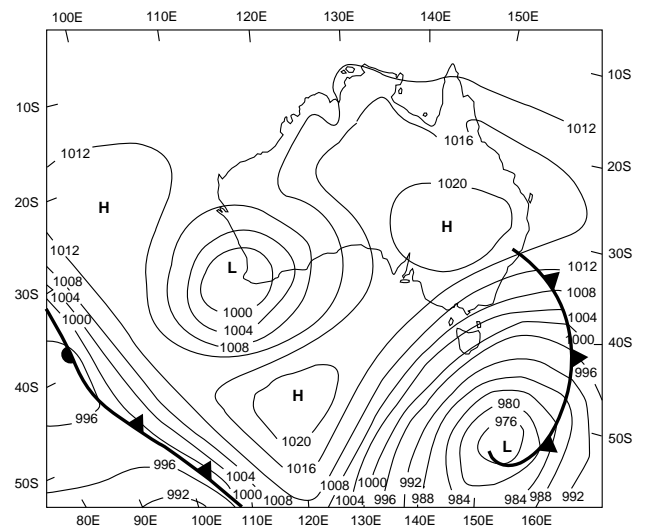


Figure 3 A winter weather map.

with their extreme dryness, creates a very high fire danger in the tropical savanna region.

- An **active low pressure system** near Perth is 'cut off' from the southern westerlies. Situations of this type may cause rain and rather cold weather over southern parts of Western Australia.

Rain or fine?

Features on the surface weather chart indicate likely rainfall patterns as well as temperature distribution and wind strength. In general, highs tend to be associated with subsiding (sinking) air and generally fine weather, while lows are associated with ascending (rising) air and usually produce rain or showers.

While cloud can exist without rain, the opposite is not the case.

Clouds form by the condensation of water vapour through cooling. Causes of cooling include:

- **Convection**, which may be caused through air mass instability. It may be initiated by warming of low-level air, forced ascent over mountainous country, or dynamic causes associated with severe weather systems. Cumulus clouds often form as a result of convection. The most exceptional forms are often associated with severe thunderstorms and occasionally, tornadoes. Cumulonimbus, for instance, may reach altitudes above 15,000 metres.

- **Systematic ascent of moist air** over large areas linked with large-scale weather systems such as low pressure systems, including tropical cyclones. In mid-latitudes this systematic ascent often occurs ahead of active fronts, or with 'cut off' lows. This type of rain may be persistent and heavy and cause floods, especially if enhanced by forced (orographic) ascent over mountains.
- **Orographic ascent** which occurs when air is forced upwards by a barrier of mountains or hills. Cloud formation and rainfall is often the result. Australia's heaviest rainfall occurs on the Queensland coast and in western Tasmania, where prevailing maritime airstreams are forced to lift over mountain ranges.
- **Cold and warm fronts** which also cause systematic ascent. A cold front is the boundary where cold air moves to replace, and undercut, warmer and less dense air. Associated cloud and weather may vary enormously according to the properties of the air masses,

but tends to be concentrated near the front. As a typical cold front approaches, winds freshen from the north or northwest, and pressure falls. After the front passes, winds shift direction anticlockwise ('backing' to the west or southwest) and pressure rises. Cold fronts are much more frequent and vigorous over southern Australia than elsewhere. Warm fronts, relatively infrequent over Australia, are usually found in high latitudes where they can occasionally cause significant weather. They are often shown on weather charts over the Southern Ocean. Warm fronts progressively displace cool air by warmer air.

- **Convergence lifting** which occurs when more air flows into an area at low levels than flows out, leading to forced rising of large air masses. Convergence is often associated with wave-like disturbances in tropical easterlies and may also occur with broad tropical air masses flowing to the south. Given sufficient atmospheric moisture and instability, it may cause large cloud clusters and rain.

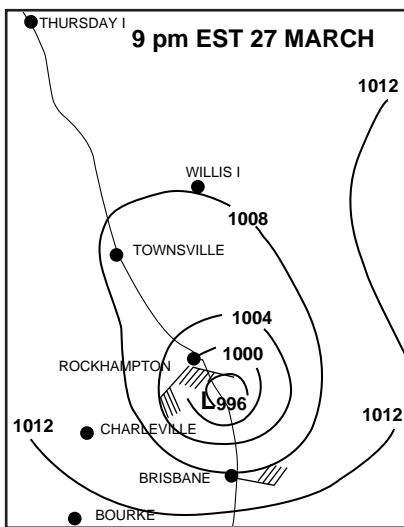
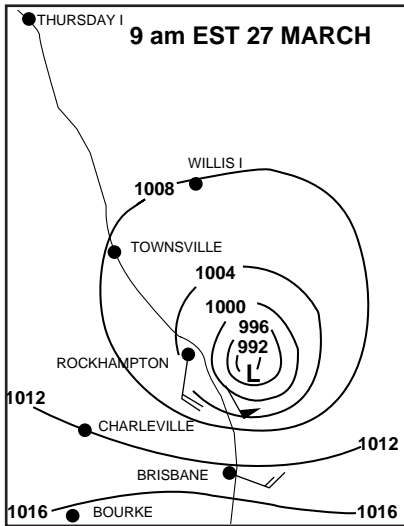
How strong will the winds be?

A mean sea level pressure chart shows the direct relationship between isobar spacing (pressure gradient) and orientation, and the strength and direction of surface winds. The general rule is that winds are strongest where the isobars are closest together. Thus the strongest winds are usually experienced near cold fronts, low pres-

sure systems and in westerly airstreams south of the continent. Winds are normally light near high pressure systems where the isobars are widely spaced.

However, because of a latitude effect winds in middle latitudes are lighter than those in the tropics with similarly spaced isobars.

In Australia, the most destructive winds over broad areas are generated by tropical cyclones. (Tornadoes, associated with some severe thunderstorms, have the potential to generate higher wind speeds, but areas affected are much smaller than these tropical storms.)



Figures 4 (a) and (b)

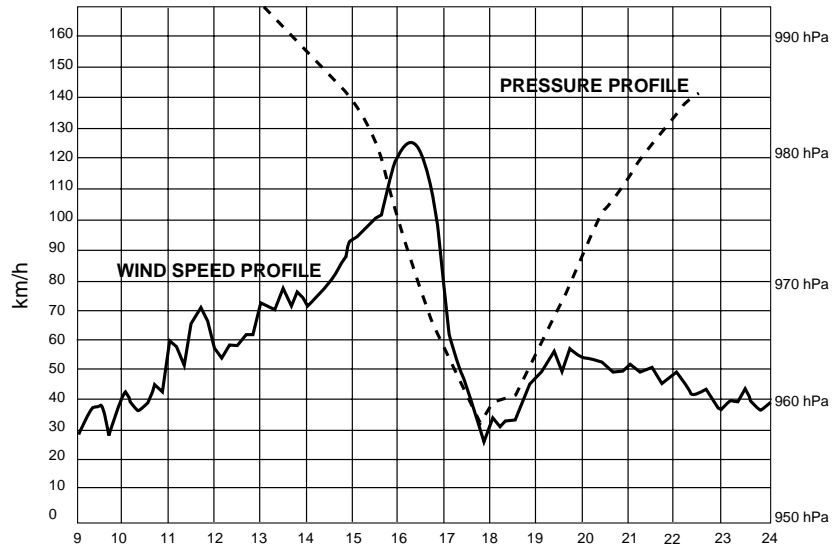


Figure 5 Typical wind speed and pressure relationships for a tropical cyclone - cyclone *Winifred*, Cowley Beach, Queensland, February 1986.

Tropical cyclones are low pressure systems in the tropics which, in the southern hemisphere, have well defined clockwise circulations with mean surface winds (averaged over ten minutes) exceeding gale force (63 kilometres per hour) surrounding the centre. Tropical cyclones exhibit a relatively clear eye, surrounded by dense wall clouds and a series of spiral rain bands. The Bureau tracks cyclones with weather watch radar, special service reports and frequent satellite images. Figures 4(a) and (b) show a tropical cyclone approaching, and crossing the Queensland coast near Rockhampton. The pressure gradient is very steep towards the cyclone's centre and wind

speeds on the nearby coast in this case would have been about 110 kilometres per hour with gusts 50 per cent or more above this mean wind speed. In Figure 4(b), 12 hours later, the cyclone has moved inland. Cut off from its heat energy source, the ocean (it requires sea-surface temperatures above 26.5°C), its intensity has decreased and wind speeds have dropped to 85-90 kilometres per hour. Figure 5 graphs the relationship between wind speed and pressure as the eye of tropical cyclone *Winifred* crossed Cowley Beach, in Queensland, in February 1986. The relationship is characteristic of tropical cyclones.

Using weather charts

Preparation of weather charts which predict surface and upper level flow patterns up to several days ahead is integral to weather forecasting. The best and most objective way of doing this is to use computer models incorporating the equations which represent the motion of the atmosphere, and its associated physics. The Bureau's supercomputers run mathematical models on a global and regional scale for both daily forecasting and for research

While predicted (prognostic) weather charts are essential to the forecast process, they must be interpreted by meteorologists to prepare specif-

ic weather forecasts and warnings. Forecast errors still occur, due to limitations in data or the forecast models, and the inherent complexity of the atmosphere, but forecast accuracy has increased very significantly since the introduction of satellite information and mathematical modelling. Prognostic charts shown routinely on television and in newspapers predict conditions up to three days ahead.

An inexpensive aneroid barometer enables weather map watchers to follow changes in surface air pressure over time, giving important clues to subtle alterations in weather systems.

By combining information from the barometer, weather maps and forecasts from the media, and personal experience from sky watching, they can make the most of the Bureau's weather service.

It will be realised by now that a single weather map is only a forecasting aid and that a great deal of other data and information must be gathered and processed before a forecast is issued. However, the information in this leaflet should assist in understanding and interpretation.

For further information contact the Bureau of Meteorology Regional Office in your State or Territory