Cold Fronts

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For the maritime community the cold front is one of the most significant features that can be seen every day throughout the year on the Bureau's weather map.

These fronts mostly affect the southern waters surrounding Australia, but from time to time, especially in the winter and spring months, can penetrate well north into tropical areas. Unfortunately few seafarers fully understand what these fronts are and what to expect when they are encountered when sailing around the Australian coast.

A front is simply the way forecasters represent the boundary between two different air masses. It may be moving, in which case the front is named by the advancing air mass – cold or warm – or it can be stationary, with neither air mass advancing. In Australia cold fronts are far more common than warm fronts.

For those who have looked at the classic textbook descriptions of cold fronts, you may remember the simple explanation given was of an advancing cold air mass pushing under an existing region of warmer air. This lifting of the warm air frequently produces a band of cloud with accompanying showers or rain.

The textbook description, although accurate in broad terms, does not fully explain the sometimes-severe wind changes experienced along the NSW coastline, particularly during the warmer months. Two important factors of the weather situation largely determine the nature of these changes. The first of these relates to the properties of the air mass ahead of the change – it may not be moist or unstable enough to form cloud or rain, even when forced to rise.

The second factor is the depth of the advancing cold air. In NSW during summer the advancing cold air is often very shallow, with sailors experiencing effects that differ greatly from those that would be expected, based upon the earlier mentioned simple description of the passage of a cold front.
The idea that a front is a single boundary is also frequently incorrect with the concept of a transition zone or frontal zone being more appropriate.

These frontal boundaries are seldom constant in their characteristics. They are continually progressing through a sequence of intensification, then decay, and will periodically completely dissipate or regenerate from an initially very weak change as they move across the waters.

Winds on each side of a front can increase the temperature difference across the front, which leads to a rapid strengthening of the front. Alternatively, a front may run up against a large slow-moving high-pressure system, known as a blocking high, which causes the front to stall then quickly dissipate.

These and other more complicated factors make forecasting the arrival of a wind change (although vague and ambiguous, arguably a better term than front for the NSW coastline) a more complex matter than simply calculating its speed and extrapolating its movement across land and ocean.

South Australia and Victoria

The structure of the cold fronts that affect South Australia (SA) and Victoria during the summer was investigated during a field study called the Cold Fronts Research Program (CFRP) during the years 1980, 1982 and 1984. Two types of cold fronts were identified from this study.

The first was a cold front with an associated frontal transition zone. This was the most common type. A model of the structure of the frontal transition zone has been developed and is shown in Fig. 1.

The transition zone typically extends for approximately 300k ahead of the front and contains discontinuity in wind, pressure temperature and humidity. This discontinuity is usually associated with bands of convective cloud (cumulus clouds, sometimes appearing from the ground as a series of lines of showers that would rapidly move through).

CFRP studies indicate that; the speed of movement of the most significant frontal change depends on the orientation and strength of the winds behind the front and the extent to which the winds ahead of the front blow against the direction from which the cold front is approaching.

The second type of front has a structure similar to a shallow layer of cold air sometimes only about 900 metres thick – which slides under warmer air ahead. It can be thought of as an airflow whose speed depends on the density difference between the cold and warm air and the depth of the cold air, referred to as gravity currents in scientific circles. Winds ahead of the front also influence the front's speed.

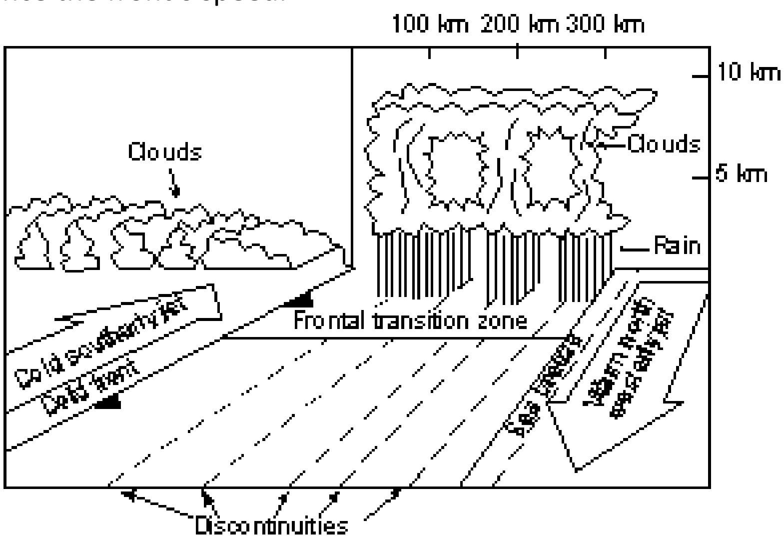

Fig. 1 The structure of summer time cold fronts over south-eastern Australia.

A very strong pressure gradient occurs in the air immediately behind the front and usually there is little or no precipitation with this type of change. This type of front may often be experienced when sailing across Bass Strait during the warmer months, sometimes accompanied by a roll cloud and nearly always with strong winds. At times it will precede the first kind of front mentioned above by a number of hours, typically three to six hours.

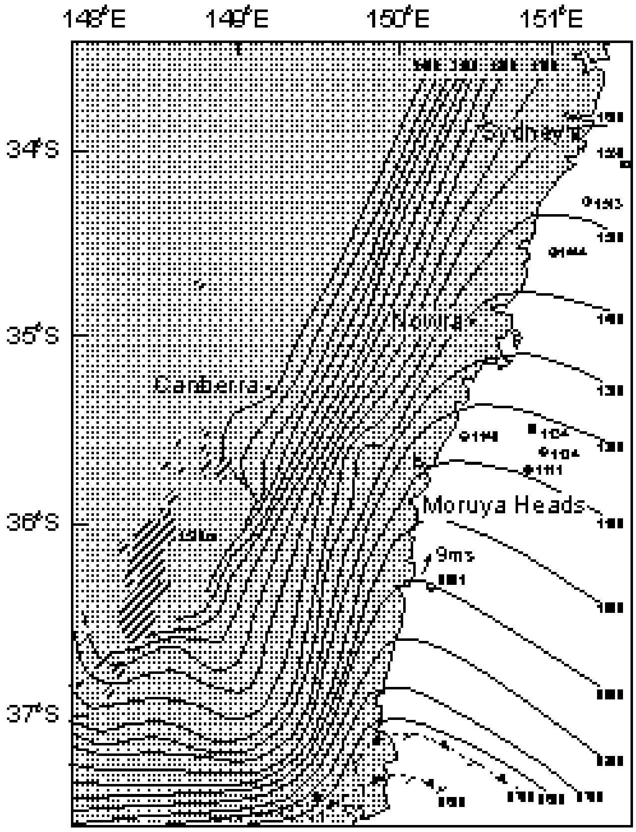

Fig 2 Progressive positions of a shallow cold front from 6 a.m. to 1 a.m. the next day.

New South Wales

The second type of front described above is often not the result of a front originating in the Southern Ocean. Many of them form ahead of a major frontal system somewhere over central southern Australia, even as far east as Victoria or close to the NSW coast and are sometimes associated with small low pressure systems.
These shallow fronts, besides being the most common summer-time front in NSW are also the most difficult cool change to forecast, as they may not exist 24 hours before the change arrives.

A significant problem in forecasting the movement of shallow fronts across NSW is that the mountains of south-eastern Australia retard their progress. Because of this, the fronts develop a distorted shape as they move northwards along the NSW coastline – see the surface synoptic chart in Fig. 2.

In these situations locations close to the coast receive the wind change long before the air behind the front becomes deep enough to move inland as far as the mountains.

Southerly Buster

The most famous of the shallow fronts affecting NSW is the Southerly Buster (also known as the Southerly Burster) which is a change characterised by the sudden onset of strong southerly wind squalls as it speeds along the NSW coast.

Numerous Sydney to Hobart yacht race fleets have experienced a Southerly Buster a short time into the race. The southerly winds are cool, originating from over the sea and usually replace warm to hot north-westerly to north-easterly winds ahead of the front. The winds behind the change are very gusty and frequently reach at least 30 knots, with wind squalls up to 72 knots having been recorded. The strong and gusty winds may last for several hours.

Temperature changes with the southerly buster can be dramatic. A fall in temperature of 10º to 15ºC in a few minutes is common. Southerly Busters are most intense during the afternoon as this is when the temperature difference between the pre-frontal and post-frontal air will be greatest and this is one of the contributing factors to the speed and strength of the front.

The meteorological conditions ahead of fronts can vary considerably. Strong north-westerly winds and hot conditions are quite common. However, if the winds are not strong, sea-breezes may develop close to the coast and moderate temperatures by 10º to12ºC. A short distance inland (10–20 kilometres) the temperature may still be very high.

The moisture content of the pre-frontal air can also vary a great deal with consequent differences in the weather. The hot north-westerly winds are generally dry but when they are moist, conditions can be cloudy to overcast with some rain or scattered thunderstorms possible.

There are a few useful features of Southerly Busters affecting NSW:

- The speed of movement of the frontal wind change in the afternoon can be double that of the morning.
- Post-frontal winds can vary quite markedly as one moves from several kilometres offshore to inland areas. Offshore, wind directions can be anywhere from the south-west through to the south-east. Near the coast, winds tend to be strong southerly with the winds becoming lighter and turning progressively to the east north east as the change reaches the Blue Mountains.

West of the mountains, post-frontal winds are generally south-westerly. The difference is post-frontal winds east and west of the mountains can sometimes mean that the mountains may receive either an easterly or westerly wind change depending on which change moves through first.

The air behind Southerly Busters can exhibit horizontal roll vortices, which are rotating cylinders of air that have their axis parallel to the ground. Fig. 3 shows a vertical cross-section through the type of front typically experienced near the NSW coast. Streamlines show airflow relative to the circulation centres.

The front is moving towards the left-hand side of the page. There is ascending air immediately to the south of the front at the head of the first roll vortex, and coincident with the greatest instability.

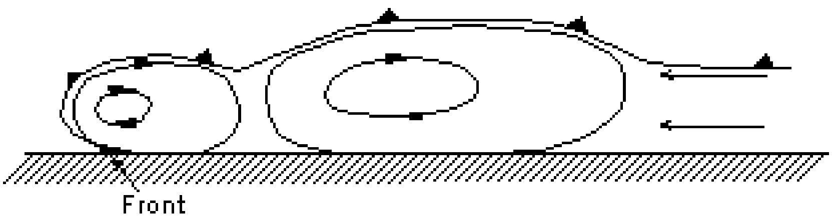

Fig. 3 Vertical cross section through a typical NSW coastal front.

The horizontal portions of the vortices can produce occasional brief lulls or short-lived increases in the surface wind speed. It must be emphasised that roll vortices are not associated with every front or Southerly Buster. Also not all Southerly Busters are associated with a roll or shelf cloud as many move along the coast cloud free.

- The pre-frontal air may not be unstable or moist enough to produce any showers or thunderstorms and for some time after the frontal passage the new air mass may not be deep enough for any significant cloud to form.

However, a reasonably common occurrence is for a shallow layer of low cloud to come in with the change. One of the sure signs that the change is approaching is the sight of shreds of low cloud scudding from the south towards you. Once the change deepens sufficiently, this low cloud may thicken and drizzle or showers may form, depending on the characteristics of the post-frontal air.

Monitoring the location and movement of shallow fronts at sea is very difficult. Cloud, if present, is the most reliable indicator, with low cloud lines marking the surface position of the change.

Changes in atmospheric pressure as observed on the aneroid barometers used mostly on boats are not reliable indicators of the approach of the shallow fronts that frequent NSW waters, as they often do not produce a large pressure fall. During daylight hours a decrease in the horizontal visibility to the south coupled with a darker coloured sea surface, may give you a clue. It could be the only time in a race that you wished to have someone in front of you.