ISOBARS AND THE WIND

ISOBARS AND THE WIND

Isobars can tell us about the wind. It was Buys-Ballot (1818–90), a Dutch meteorologist, who in 1857 made the vital link between isobars and wind. In the Southern Hemisphere, his rule is as easy to remember as three L's:
• if you LOOK into the wind, the LOW pressure is on your LEFT.
However, estimating the winds from the isobars is not merely as simple as Buys-Ballot's law. Here are seven wind-reading tips:

1. Wind FOLLOWS the isobars. This is simply Buys-Ballot's law again. In the Southern Hemisphere, the flow is CLOCKWISE around LOWS and counter-clockwise around highs. (In the Northern Hemisphere, the flow is the other way round.) But, in the tropics, the forces that balance the wind (namely pressure difference and the vertical component of the rotating earth) are weak. And, at the equator, the wind blows in straight lines. Note that this tip applies to the freely flowing wind (above about 1000 m / 3000 ft over open sea) which is not affected by the drag of the ground. For surface wind direction see tip 3.

2. The closer the isobars, the stronger the wind. This varies with latitude. On a weather map with isobars 5 hPa apart, a spacing of three degrees latitude (with straight isobars) means fresh winds about Auckland, but the same spacing means a gale over Fiji.

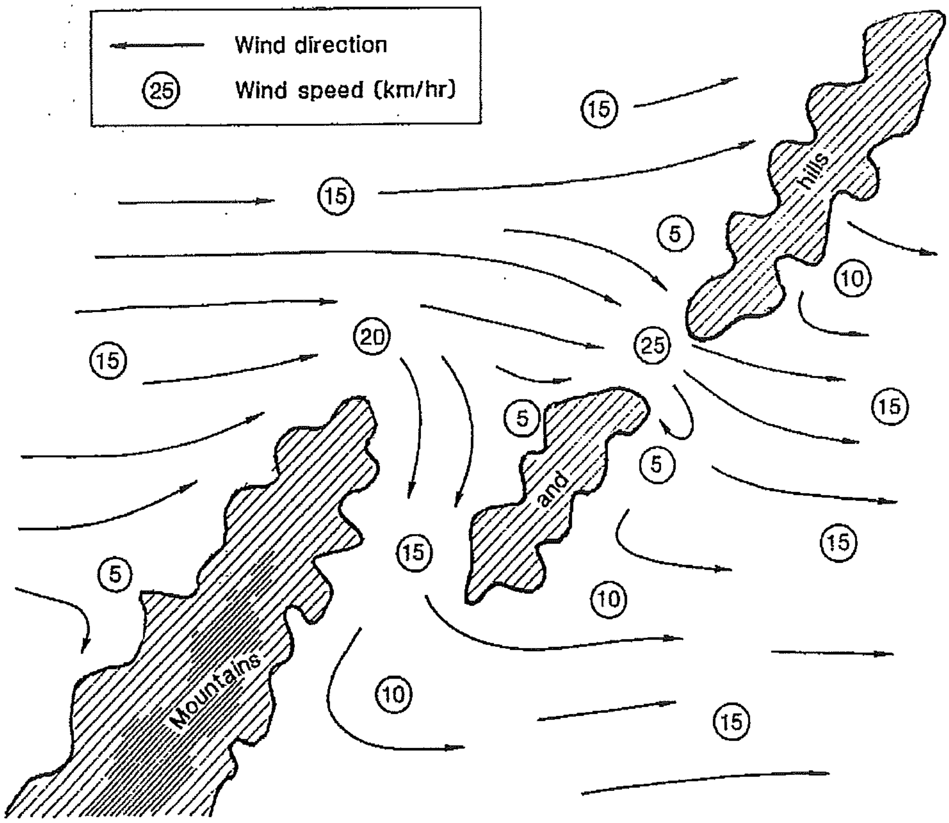
3. Surface wind "leaks" across the isobars towards low pressure. This is because of the drag or friction effect below 1000 m (3000 ft). The amount of "leak" is about 15–20° over the open sea, but as much as 30–90° over and around land. (There are 360° in a circle.)

4. Because of the "spin-out" effect when turning corners, wind speed becomes higher as the air turns around (and out of) a high (by as much as 20%). Similarly, wind becomes lower as it curves around (and into) a low (by as much as 20–40%). This means that the strongest winds around a low are usually found some distance away from the centre. In tropical cyclones, the wind maximum is in a ring around a central calm.

Rules 1 to 4 can be used to estimate wind from isobars over the open sea. This has been summarised on the METSERVICE Wind Scale found at the back of the book.

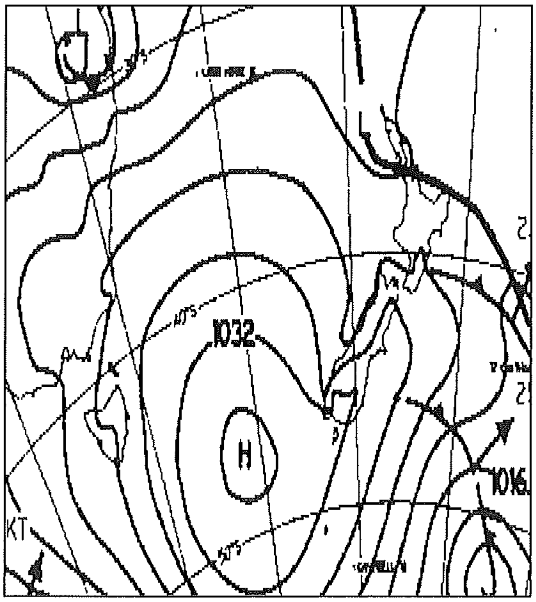
5. Terrain effects: Isobars are only smoothed-out approximations, and only tell us about the general wind flow, not the details. Wind flow over land is not simple — it is like water flowing over a rocky brook, eddying around corners and rushing between boulders. Actual wind accelerates down valleys, bends around headlands, bumps about abutments, is contorted by the coastline, dips and dives over hills and dales, eddies behind mountains, and gallops through gaps. There is a natural reluctance for surface wind to move over land in the cool of the night or near dawn, and it may be drawn onshore during a hot day (sea breeze), or offshore at night (land breeze). Mountain air cooled at night sinks down valleys and drains out to sea (katabatic wind). These effects do not show up in the isobars on the weather map, but can halve or double the local wind speed and distort its direction (always towards low pressure).
Be especially wary when seeking shelter in the lee of a range of hills.

6. **Rivers of wind - puddles of calm**
There is one terrain effect that does show up on the weather map. Chains of mountains distort isobars that cross them, buckling the isobars so that there is a build-up of pressure on the windward side and a counterbalancing drop of pressure downwind from the mountains. The trough of low pressure downwind of a mountain range is called a **lee trough**. Because of this distortion, isobars over mountains do NOT indicate the actual wind direction. Those isobars are MSL (mean Sea Level) so technically do not apply to high ground. Also, when the wind does get a chance to flow around mountains it flows directly from high pressure to low pressure (this is called ageostrophic flow).



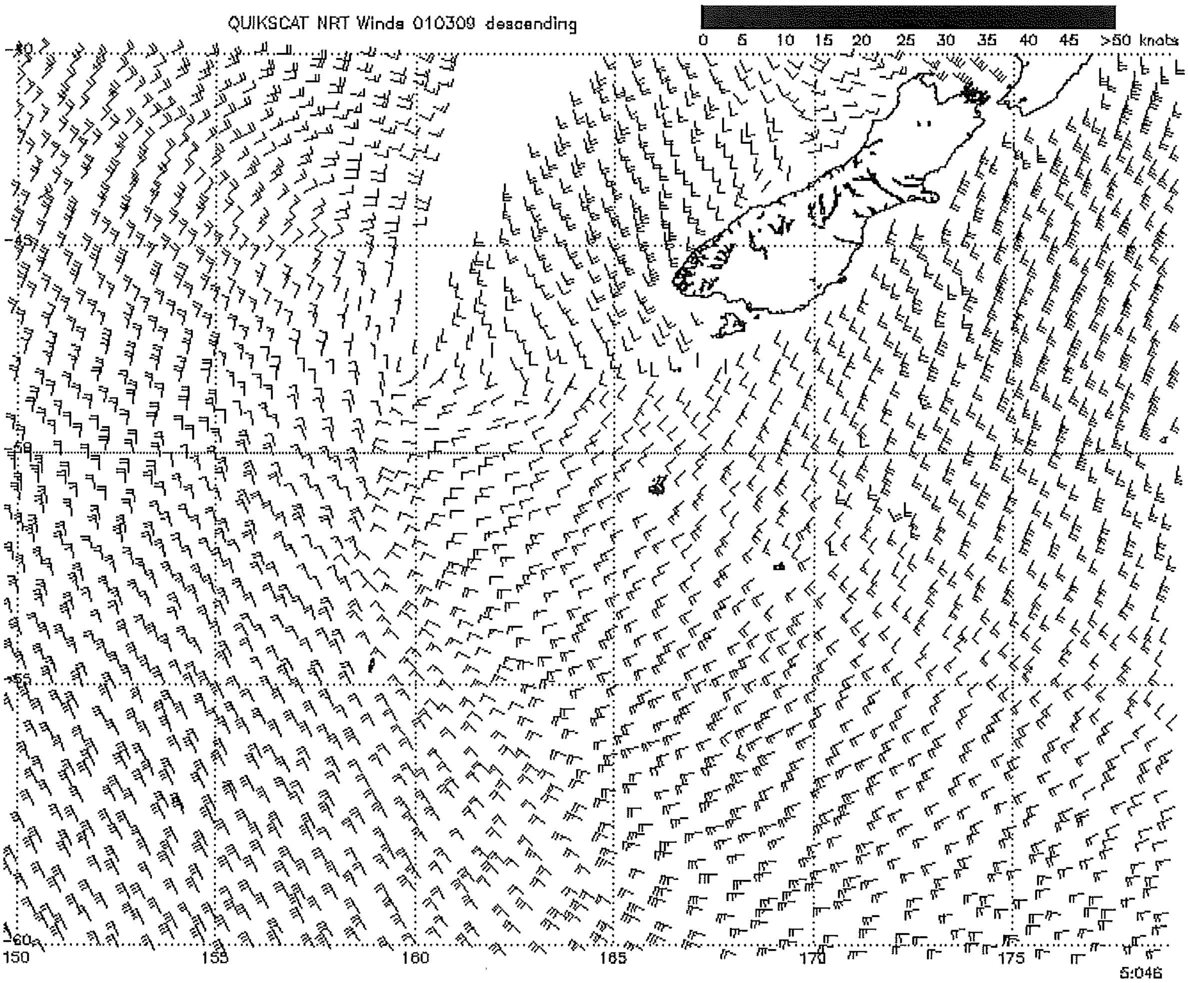
Puddles of calm form naturally enough in lee of the mountains. When the wind flow is blocked by a mountain chain, some air rises up and over the mountains (helping rain fall on the windward side so that drier air reaches the downwind side) but much of the air is deflected around. This shows up as something resembling a "river of wind" over the sea at the **downwind** end of the chain. The river is usually strongest at that end of the mountains which has the highest air pressure. It is usually in the order of tens of kilometres wide and hundreds of kilometres long. When isobars crossing a mountain chain are also curving around a high-pressure area, less air rises over the mountains and thus more air feeds the "river of wind" so that, beyond the lee trough, wind speed may be in the 30 to 40 knots range, even though coastal land stations may only be reporting about 10 knots.

To spot "rivers of wind" look for isobars crossing a mountain range. The wind-river is located over the sea at the downwind end of the mountain range. It is strongest when isobars are also curving around a high-pressure area.



On this weather map (MetService 9 March 2001) the central pressure in the high is over 1036 – a sure sign that there should be a gale somewhere ("pressure over one-thousand-and-thirty, the weather's getting dirty"). At first glance the isobars do not indicate where the gale could be. However the "kinks" in the isobars over the South Island mountains indicate that there is a river of wind flowing DOWNSTREAM from that end of the mountain chain, which has the highest pressure (in this case the SW tip of New Zealand).

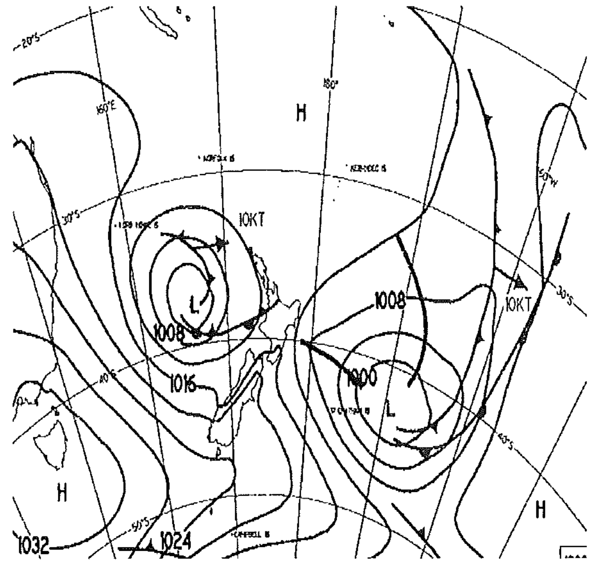
The wind map from the QuikSCAT scatterometer web site at *http://manati.wwb.noaa.gov /quikscat/* reveals the full extent of this river of wind and shows some puddles of calm.

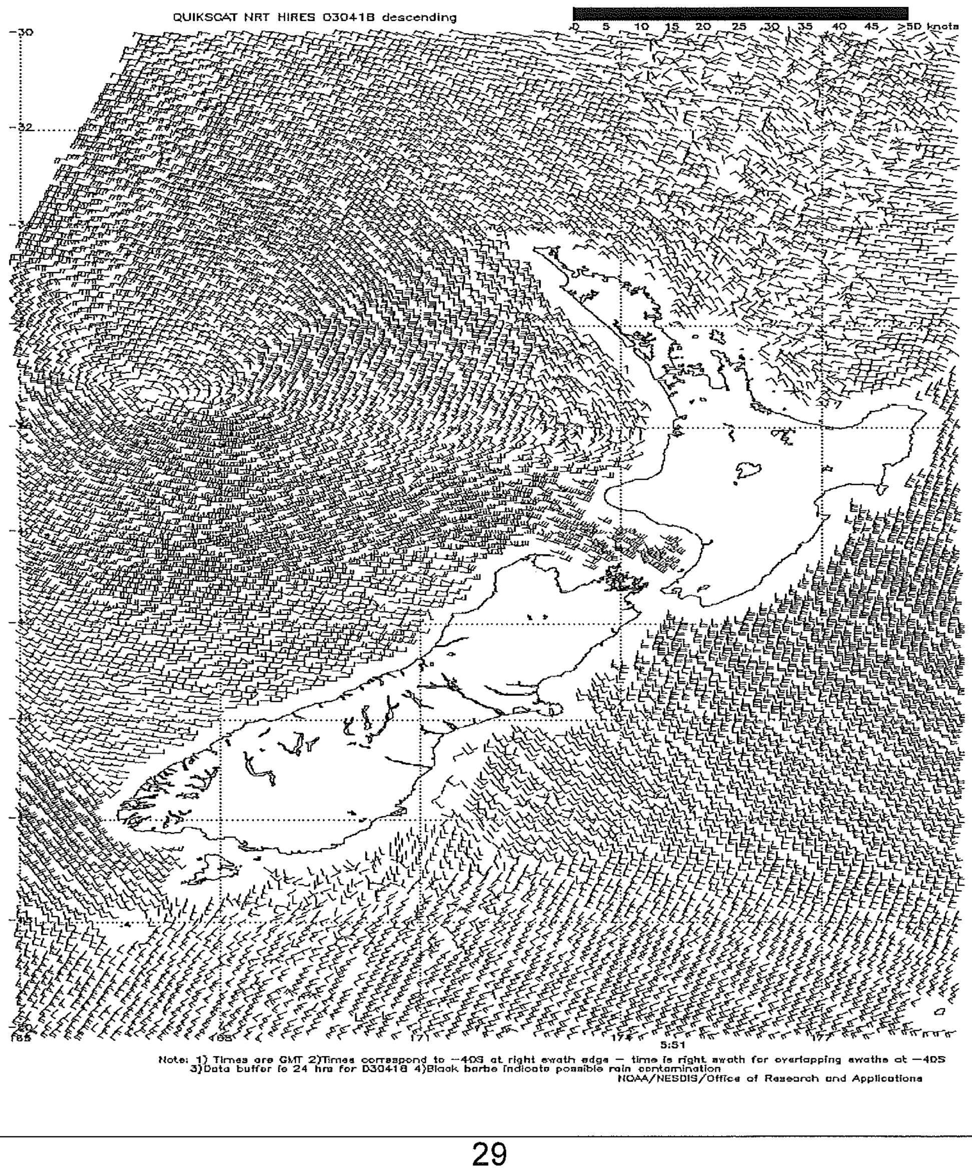


Note: 1) Times are GMT 2)Times correspond to –50S at right swath edge – time is right swath for overlapping swaths at –50S 3)Data buffer is 24 hrs for 010309 4)Black barbs indicate possible rain contamination
NOAA/NESDIS/Office of Research and Applications

Enhanced river of wind

In this example, the low-pressure region west of the North Island is deepening and the river-of-wind through Cook Strait is enhanced as a consequence. Notice how there is another river-of-wind flowing northwestwards from southern New Zealand. These rivers-of-wind generate swells, and the region where these swells combine is particularly liable to have choppy confused seas with the occasional huge wave. In this case a Taiwanese fishing boat was sunk and all 18 souls on board were lost. *Case study 18 Apr 2003. (Good Friday) Isobar map from MetService and wind map from QuikSCAT scatterometer 25km resolution site http://manati.wwb.noaa.gov/quikscat/.*





7. **Squash Zones.**

No, not a zone to grow vegetables or play a game of squash. A squash zone is my term for an area where isobars get squashed together, and thus form strong winds.

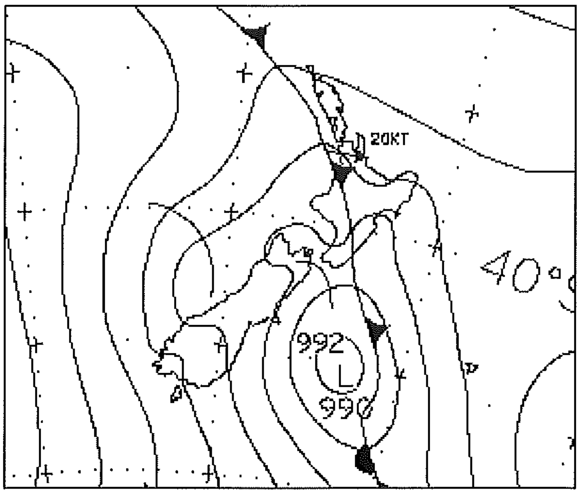
• Squash Zone 1 "Waitangi Day" 2002

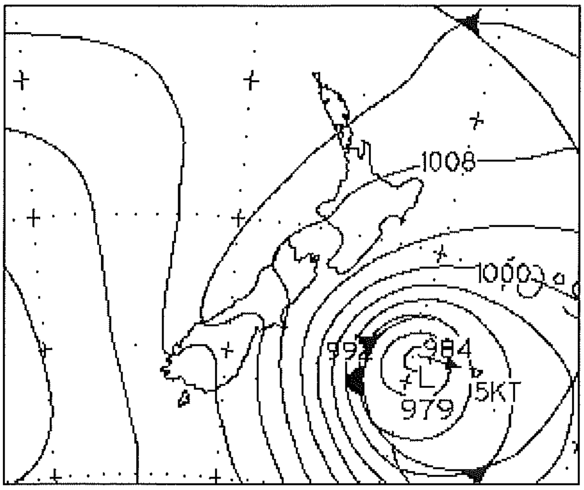
This is the easiest to explain. Isobars around the low east of the South island of New Zealand are already close together. The low is almost stationary and deepening (drops from 990 to 972 in 24 hours). But the pressure over the New Zealand mainland is rising because of an incoming high pressure (Auckland rises from 1004 to 1011). This means the isobars between the low centre and the New Zealand mainland are coming closer together. This "squash zone" results in strong winds over Canterbury (destroying part of the Lyttelton marina) and Cook Strait (with 8+metre waves). . The resulting swell in this case beached a freighter as it attempted to depart from the port of Gisborne.

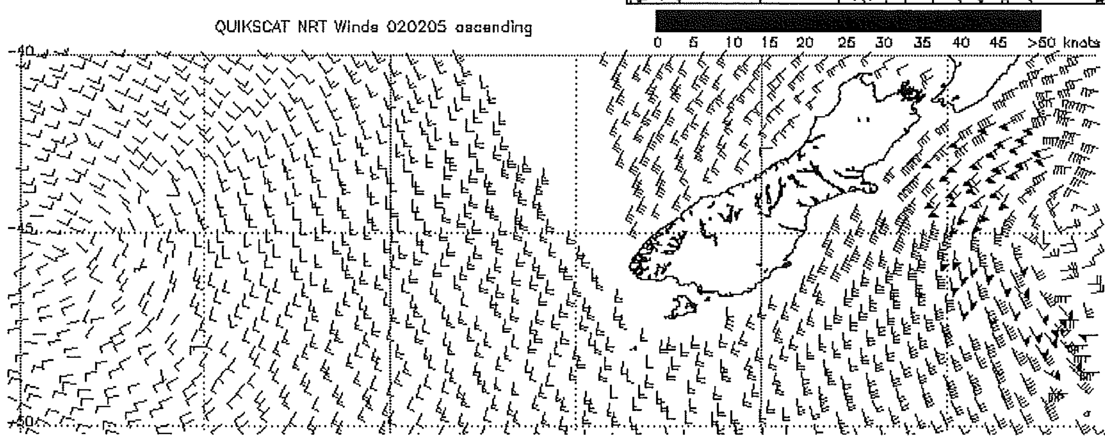
Increasing gradient between H and L

Depends on the strength of the H, and the movement of the L

Weather maps from MetService for noon 5th and noon 6th February 2002 and wind map from the QuikSCAT scatterometer archive on the web at http://manati.wwb.noaa.gov/quikscat/.

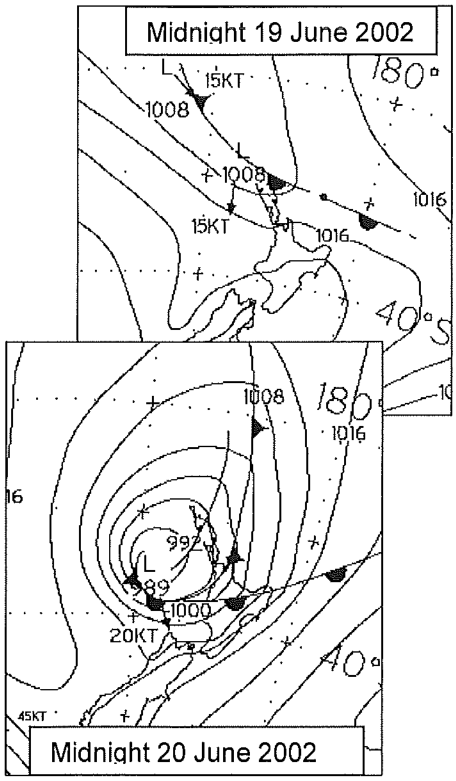


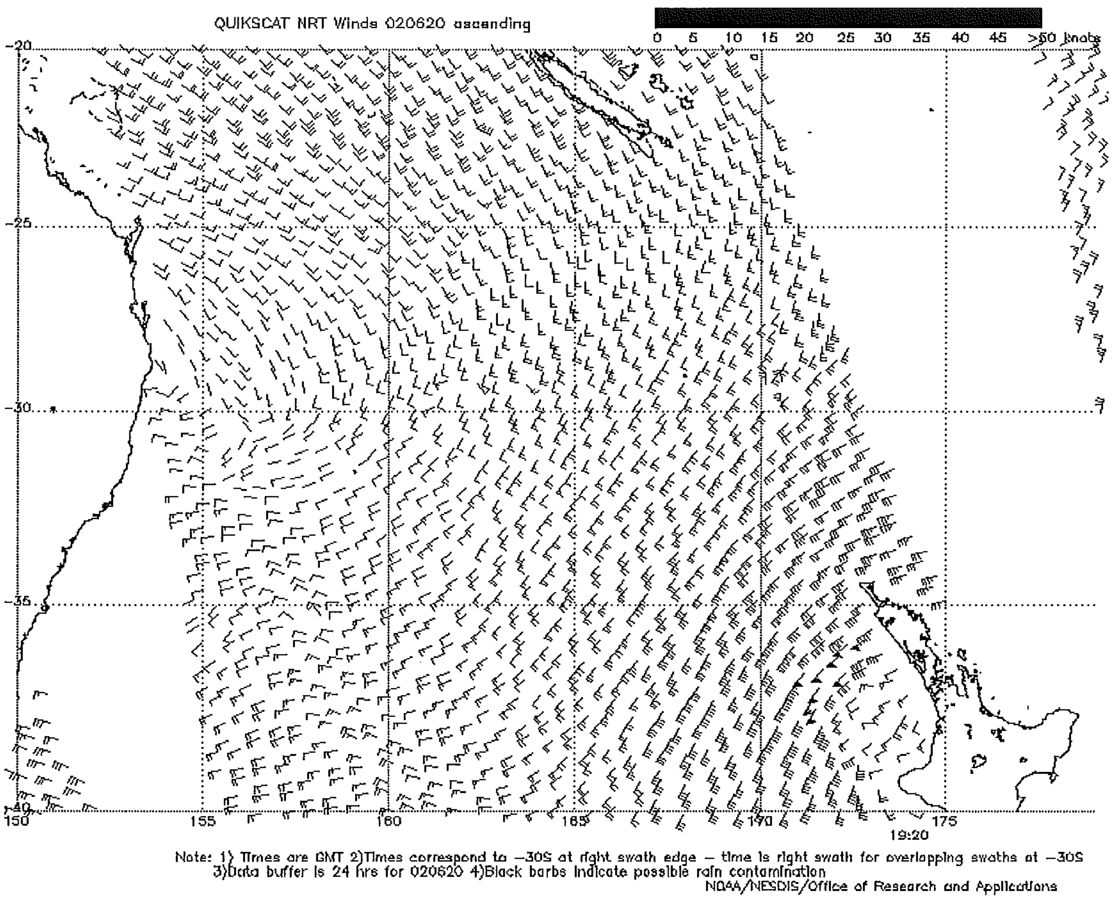




Another example of squash zone 1
A weather "bomb"

Under certain conditions an area of low pressure may deepen rapidly or "undergo explosively cyclogenesis" or "bomb". The case study on Page 59 studies the weather bomb in more detail. In this case the central pressure dropped from 1008 to 989 in 24 hours. When isobars are rapidly being added to the centre of a depression, it is clear that all the isobars surrounding the depression will end up closer together. The resulting squash zone forms in a ring around the centre – and this is an area of accelerating wind – as revealed by http://manati.wwb.noaa.gov/quikscat/, the QuikSCAT scatterometer. In this example, 20 June 2002, northern regions of New Zealand suffered millions of dollars of damage due to the wind and rain.





• Squash Zone 2
The "eggbeater'

This is the one that puts a smile on the face of Kiwi (and Aussie east coast) surfers. There is a low-pressure area moving southwards out of the tropics and into the trade wind belt. The low doesn't even have to be deep enough to have an isobar encircling it. As it moves south, the isobars on its southern side bunch together, making a squash zone in the trade wind belt. This results in a gale and forms waves over 3 metres that radiate westwards at about 500 miles per day.

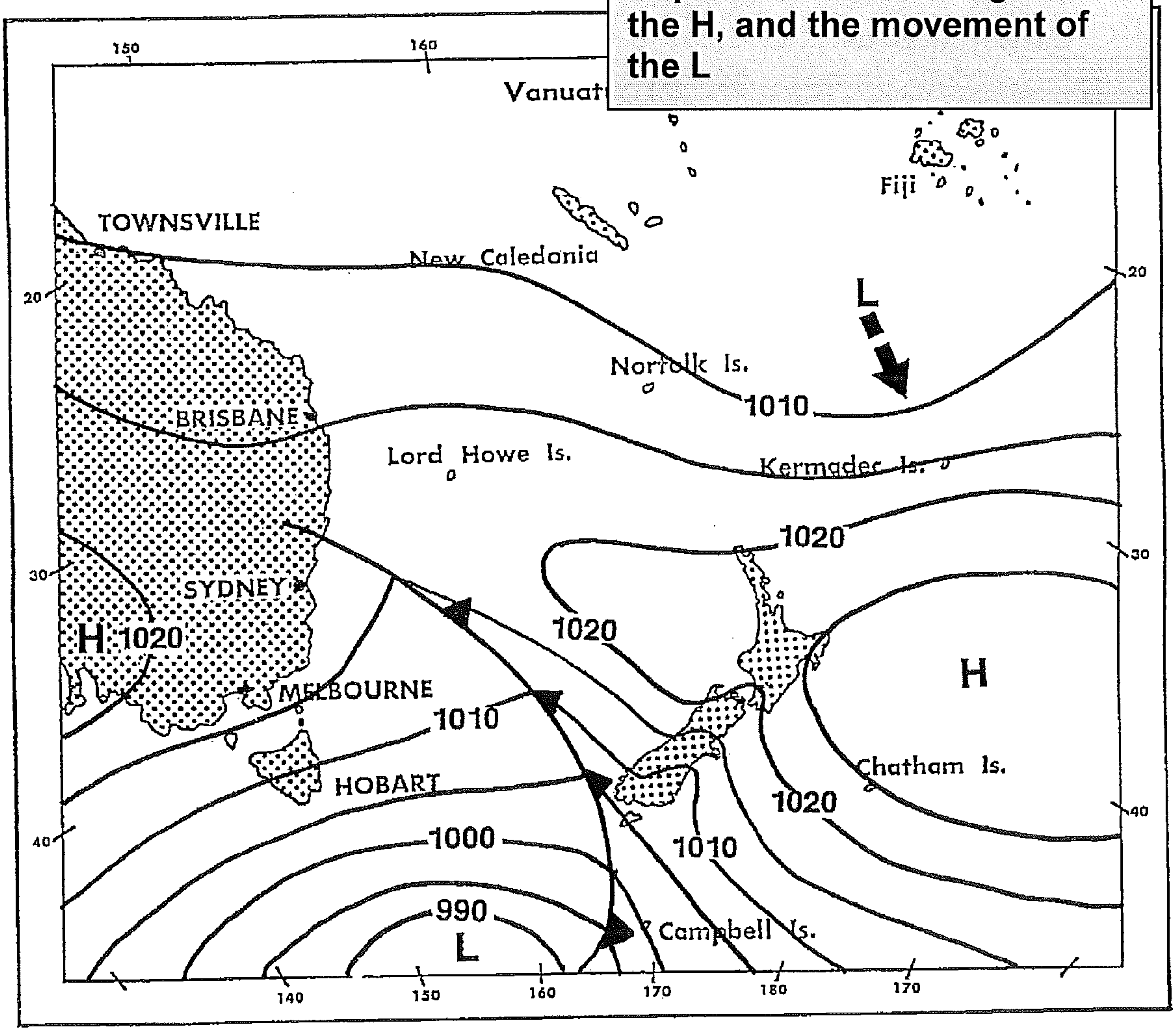
Note that the main zone of accelerating wind is where the isobars are straightest – and that this approximately half way between the low and the high pressure centres.

The acceleration effect is similar to that imposed by a hand-held eggbeater. Because the generated waves tend to pile up onto each other, the sea state becomes choppy.

In the diagram, the 1015 hPa line may stay in position over the Kermadec Islands even as the isobars in the vicinity become squashed together. This means that **gales may arrive, even though someone watching a barometer has not observed any great change in pressure.** This characteristic makes the formation of an "eggbeater" very hard to detect.

Increasing gradient between H and L

Depends on the strength of the H, and the movement of the L

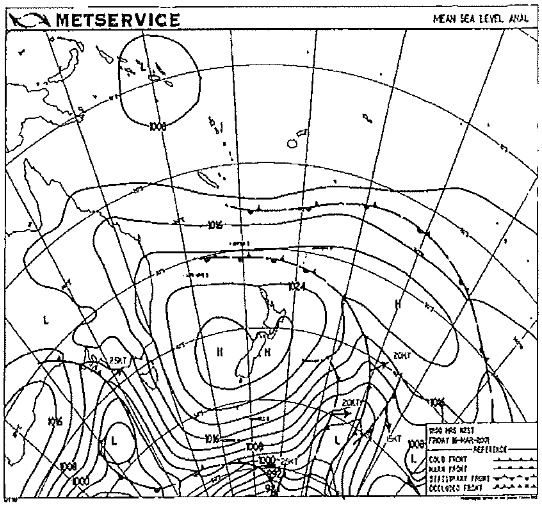


• Squash Zone 3

In the trade winds

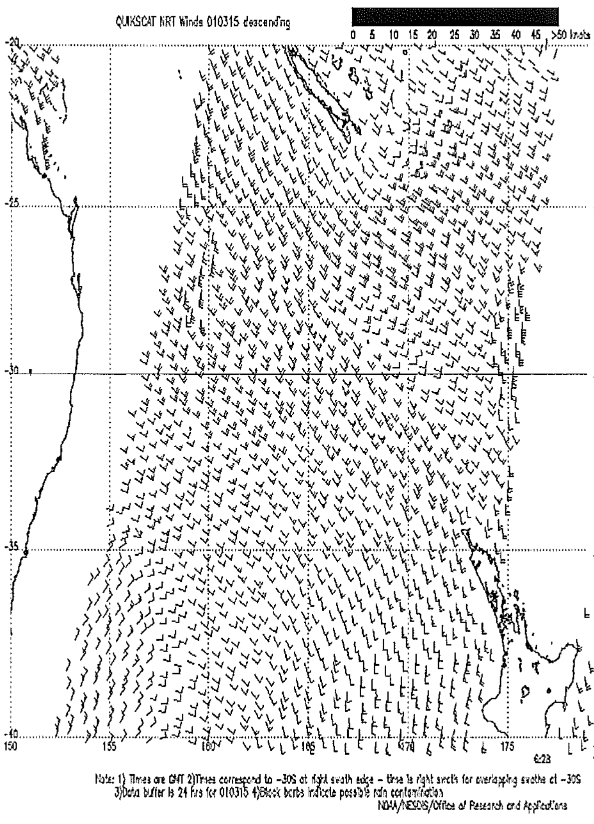
Although not as dramatic as the others, this can be inconvenient because of the lack of clues. In this case a standard high-pressure area is moving across or away from New Zealand. Note that the central pressure of this high is 1030 or more. Smoothed-out isobars have been drawn reasonably evenly spaced in the trade wind belt, because there are few observations to fit. But, surprisingly often, the actual pressure gradient (or isobar spacing) in the trade wind belt is NON-LINEAR. The trade winds are in fact banded, with zones of stronger winds flanked by weaker winds. The overall average may be 20 knots, but some sailors could be within a band of 30-knot winds whilst others (a short distance away) may only be in 10-knot winds. The QuikSCAT scatterometer (http://manati.wwb.noaa.gov/quikscat/) reveals the true mix of pattern and chaos within the "trade-wind-squash-zone". Isobaric weather maps capture the pattern but filter out the chaos.

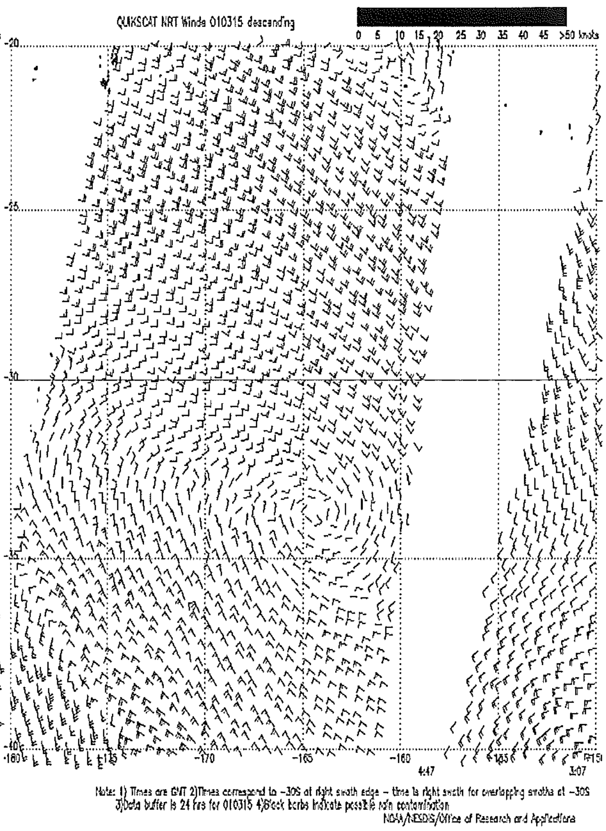
Case study 16 march 2001



Non-Linear gradient in the sub tropics

Depends on the strength of the H, and its speed of movement.





Squash Zone 3 revisited
The Bogi Walu

During the southern hemisphere winter (and the tropical dry season) the "horse latitudes" is located (on average) are along 30 degrees South (latitude), and the trade wind belt is located between 15 and 20 South. When a large high-pressure system migrates from west to east along the horse latitudes the isobars within the trade wind are forced closer together forming a trade-wind-squash-zone. Once this zone forms over Fiji it will not relax until the high-pressure system responsible moves away. The "reinforced trades" blow onshore onto the Suva coast bringing showers, especially during the night. Typically these stronger winds and nighttime showers last for a week and a day (eight nights). This is the origin of the Fiji term "bogi walu". These winds are channelled through Vatu-I-Ra Passage, across Bligh Water and onto the Yasawa Islands. Fiji Met Service often issue strong wind warnings accordingly.

Case study 12 Aug 2002. Isobar map from MetService and wind map from QuikSCAT scatterometer web site at http://manati.wwb.noaa.gov/quikscat/.