WEATHER MAPS BY FAX

Weather Fax (WEFAX)

There are still a few transmitting stations sending, by SSB radio in the public domain, signals which can be deciphered at the receiving end as charts. You can pick up all sorts of different charts on your weather fax receiver. This can be overwhelming, as most of the charts simply look like a plate of spaghetti. These notes should help you decide **WHAT** maps will help you and what maps are not worth chasing. In the Northern Hemisphere, satellite images are sent out from many WEFAX (Weather Fax) stations, but this is NOT the case in the South Pacific.

Most yachts that can receive weather fax these days do so by linking their SSB radio to a PC (personal computer) and displaying the downloaded charts on screen. The rest still use a self-contained unit that includes its own radio receiver and prints the downloaded charts as they are received. Both these systems usually have an in-built list of the frequencies used by the all the weather fax stations around the world. It is up to the user to pre-select the station and time for each chart. But the chart schedules keep changing.

HOW IT IS DONE

The (old) analogue system of producing and sending WEFAX images involves manually loading the original chart onto a drum. The drum then rotates at 120 rpm so that it takes about 12 or 13 minutes to scan one full image at a rate of 100 lines per inch. The scanning is done by a focused beam of light. The light reflects back to a photocell, which varies its voltage output according to the amount of light reflected from the image. The voltage variations are then amplified and used to modulate an audio signal broadcast in short-wave.

These days several WEFAX stations (including ZKLF) use a digital system for producing and sending images. The image is stored in a computer as consisting of pixels (picture elements). The audio signal that is broadcast in short-wave is sent out at the standard rate (as used for analogue generated WEFAX) and modulated by the value of each pixel in turn. Timing of transmissions is by a computer clock.

When you hear a fax signal it has a characteristic beat of 120 cycles per minute, with a scratchy sound between beats. The beat is the "sync pulse" that defines the edges of the transmitted image, and the scratchy tone is the image data: the higher this tone, the whiter the image.

TUNING IN

To receive WEFAX signals properly, your short-wave radio must be able to capture single sideband (SSB) signals. SSB transmissions use only one side of a carrier signal, usually the upper, saving precious space in the crowded radio frequency spectrum. If you use regular waveband mode to listen to voices sent on a SSB broadcast, you hear Donald Duck-like squawking. The voices sound normal only in SSB mode. Similarly, a chart sent via WEFAX only appears correct when you tune to it in SSB mode.

*To get proper tonal reproduction from some WEFAX stations you need to tune into the upper sideband **1.6 or 1.9 kHz** below the published frequency. Tuning 1.6 or 1.9 kHz above the frequency results in a negative image. (For most WEFAX SSB stations Carrier frequency is 1.6 or 1.9 kHz below published frequency).*

If your SSB radio only has a whip antenna this may not be good enough

to receive a workable signal far from the transmitter. A simple long-wave antenna may be needed, —the longer the better. Try stringing an insulated copper wire up the backstay.
As a rule: choose lower frequencies at night and higher ones during daytime. Nighttime reception seems to be less consistent than daytime. The transmitters are sometimes a bit off the quoted frequency, so if the chart is really important then nurse the reception signal yourself and make minor tuning adjustments to optimise reproduction.

RECEPTION BY COMPUTER
Rather than spending more than $1000 on a dedicated self-contained weather fax receiver, you can acquire a package that links your SSB to your PC for a few hundred dollars. The charts that appear on screen may **not** be as sharp as those printed on a fax receiver, but you can use your computer to auto-load, store, study, and manipulate them.
The system requirements for most of these packages are: a computer with its own operating system and a floppy disk drive, 512kB RAM, a serial port (mouse port) and a video display. A hard drive and a printer are also recommended but not necessary.

The pack includes a hardware part and a software part. The hardware is an interface (or signal demodulator) that links the radio to the computer. This converts the audio signal into a digital series of pulses. Plug its serial cable into the serial port of your computer (mouse port). It is important to do this when the computer is NOT turned on (to prevent spikes). Run a line from the demodulator to the radio's external speaker or (better) earphone jack. The software part is a program on a disk (hopefully one that can be transferred to your hard drive).

Load this and set its parameters then it allows you to receive, manipulate, and store images; some allow up to 16 level of grey (which is good for satellite images).
Each image takes about a quarter of a megabyte to store. WEFAX images are sized for the 18-inch wide paper of self-contained radio fax machines and most software programs come up with REDUCED versions to fit them on your screen. This means some of the writing and small details are nearly impossible to read. METSERVICE are experimenting with different fonts to make your images as readable as possible.

If you have any comments or suggestions please send them (and example received maps) to:

METSERVICE
Data Flow Manager
PO Box 722
Wellington
New Zealand

On the next page is a list of stations around the Pacific that send **satellite pictures** by WEFAX.

This is followed by a few pages giving the main weather fax stations that can be received in the South Pacific region, and the time UTC that a copy of their latest fax schedule is transmitted.

It can be difficult to receive a good copy of a fax schedule via radio fax. So the latest available schedules for Australia and New Zealand stations are included in this book's last chapter.

Satellite Pictures by Radio Fax

Station (see prior page for info)	Time Sent UTC	Valid Time	Description
GUAM1	----/1300	12	GMS (sector A)
	0150/1350	00/12	GMS (SECTOR AIJ)
	0205/1405	00/12	Micronesia(VV/IR)
	0320/1520	02/14	FULL DISK(VV/IR)
	0405/----	03	GMS(Sector IJ)
	0450/1650	03/15	GMS(Sector A)
	0745/1945	06/18	GMS(Sector A)
	1000/2200	09/21	GMS(Sector A)
GUAM2	0540/1740	03/15	N. Indian Ocean
	0555/1755	03/15	S. Indian Ocean
	0820/2020	12/00	DMSP 6.7nm
	0935/2135	09/21	GMS(Sector A)
Pearl Harbour	0015(Tue)	2100	GMS (Sector B)
	----/1215	1159	GOES IR(Sector C)
	0030/----	2359	GOES VISUAL(Sector C)
	0245/1445	00/12	GMS(Sector B)
	0600/----	0529	GOES IR(Sector C)
	----/1800	1729	GOES VISUAL (Sector C)
	0900/----	0859	GOES IR(Sector C)
	----/2100	2031	GOES VISUAL(Sector C)
	1045/----	0928	GMS (Sector B)
Tokyo1, Japan	0110/1310	00/12	GMS
	0710/1910	06/18	GMS
Beijing, China	0300/----	(1May-30Sep)	
	0724/----	(1May-30Sep)	
Buenos Aires,	----/1400	1200	NEPHANAL
Argentina	----/1850	15-18	NEPHANAL
	----/2200	18-21	NEPHANAL
	1030/----	00-09	NEPHANAL
Santiago, Chile	1940/----	1200	NEPHANAL

List of Weather Fax stations available around the Pacific

Country	Call Sign	Freq kHz	Times UTC	Power kW	Fax Sked UTC	As at
Darwin, Australia	AXI32	**5755**	1110-2300	10	0030	Dec95
Darwin, Australia	AXI33	**7535**	1110-2300	10	0030	Dec95
Darwin, Australia	AXI34	**10555**	24hr	10	0030	Dec95
Darwin, Australia	AXI35	**15615**	2300-1110	10	0030	Dec95
Darwin, Australia	AXI37	**18060**	2300-1110	10	0030	Dec95
Melbourne, Australia	AXM31	**2628**	24hr	10	0030	Dec95
Melbourne, Australia	AXM32	**5100**	24hr	10	0030	Dec95
Melbourne, Australia	AXM34	**11030**	24hr	10	0030	Dec95
Melbourne, Australia	AXM35	**13920**	24hr	10	0030	Dec95
Melbourne, Australia	AXM37	**20469**	24hr	10	0030	Dec95
Wellington, New Zealand	ZKLF	**5807**	24hr	5	0430; 1630	Nov96
Wellington, New Zealand	ZKLF	**9459**	24hr	5	0430; 1630	Nov96
Wellington, New Zealand	ZKLF	**13550.5**	24hr	5	0430; 1630	Nov96
Wellington, New Zealand	ZKLF	**16340.1**	24hr	5	0430; 1630	Nov96
Beijing, China	BAF6	**5525**		6--8	1158 Mon	Jun93
Beijing, China	BAF36	**8120**		6--8	1158 Mon	Jun93
Beijing, China	BAF4	**10115**		10	1158 Mon	Jun93
Beijing, China	BAF8	**14365**		15	1158 Mon	Jun93
Beijing, China	BAF9	**16025**			1158 Mon	Jun93
Beijing, China	BAF33	**18235**		6--8	1158 Mon	Jun93
Tokyo 1, Japan	JMH	**3622.5**	24hr	5	0103, 1303	Feb93
Tokyo 1, Japan	JMH2	**7305**	24hr	5	0103, 1303	Feb93
Tokyo 1, Japan	JMH3	**9970**	24hr	5	0103, 1303	Feb93
Tokyo 1, Japan	JMH4	**13597**	24hr	5	0103, 1303	Feb93
Tokyo 1, Japan	JMH5	**18220**	24hr	5	0103, 1303	Feb93
Tokyo 1, Japan	JMH6	**23522.9**	24hr	5	0103, 1303	Feb93
Tokyo2, Japan	JMJ	**3365**	24hr	5	0148	Feb93
Tokyo2, Japan	JMJ2	**5405**	24hr	5	0148	Feb93
Tokyo2, Japan	JMJ3	**9438**	24hr	5	0148	Feb93
Tokyo2, Japan	JMJ4	**14692.5**	24hr	5	0148	Feb93
Tokyo2, Japan	JMJ5	**18441.2**	24hr	5	0148	Feb93
Taipei, Taiwan	BMF	**4616**			0450	Jan92
Taipei, Taiwan	BMF	**5250**			0450	Jan92
Taipei, Taiwan	BMF	**8140**			0450	Jan92
Taipei, Taiwan	BMF	**13900**			0450	Jan92
Buenos Aires, Argentina	LRO69	**5185**	24hr	5	1430	Jan92
Buenos Aires, Argentina	LRB72	**10720**	24hr	5	1430	Jan92
Buenos Aires, Argentina	LRO84	**18093**	24hr	5	1430	Jan92
Valparaiso, Chile		**4228**			*	Oct95
Valparaiso, Chile		**8677**			*	Oct95

*MSL Analysis sent at 1110UTC, Waves analysis at 1910UTC,
*MSL Analysis and prog at 2310UTC

List of Weather Fax stations available around the Pacific

Country	Call Sign	Freq kHz	Times UTC	Power KW/SB	Fax Sked UTC	As at
GUAM 1 (Japan)	NPN	**4965**	24hr	LSB	1315, 1330	May92
GUAM 1	NPN	**5260**	24hr	L/USB	1315, 1330	May92
GUAM 1	NPN	**10255**	24hr	L/USB	1315, 1330	May92
GUAM 1 (Japan)	NPN	**12777**	24hr	USB	1315, 1330	May92
GUAM 1	NPN	**16029.6**	24hr	LSB	1315, 1330	May92
GUAM 1	NPN	**19860**	24hr	L/USB	1315, 1330	May92
GUAM 1 (Japan)	NPN	**22324.5**	24hr	LSB	1315, 1330	May92
GUAM 1	NPN	**23010**	24hr	LSB	1315, 1330	May92
GUAM 2	NPN	**5260**	24hr	USB	1320, 1335	Jan93
GUAM 2 (Diego Garcia)	NKW	**7580**	1400-0159	USB	1320, 1335	Jan93
GUAM 2 (H.E. Holt)	NWC	**8612.5**	1000-2159	ISB	1320, 1335	Jan93
GUAM 2	NPN	**10255**	24hr	USB	1320, 1335	Jan93
GUAM 2 (H.E. Holt)	NWC	**12727.5**	24hr	USB	1320, 1335	Jan93
GUAM 2 (Diego Garcia)	NKW	**12804**	24hr	USB	1320, 1335	Jan93
GUAM 2 (H.E. Holt)	NWC	**16914.5**	2200-0959	USB	1320, 1335	Jan93
GUAM 2	NPN	**19860**	24hr	USB	1320, 1335	Jan93
GUAM 2(Diego. Garcia)	NKW	**20300**	0200-1359	USB	1320, 1335	Jan93
Pearl Harbour	NPM	**4855**	0600-1600	L/ISB	0000, 0015	Nov92
Pearl Harbour (Stockton, CA)	NPM	**6453**	24hr	U/ISB	0000, 0015	Nov92
Pearl Harbour (Adak AK)	NPM	**8494**	24hr		0000, 0015	Nov92
Pearl Harbour (Stockton, CA)	NPM	**9090**	24hr	U/ISB	0000, 0015	Nov92
Pearl Harbour	NPM	**21735**	1600-0600	L/ISB	0000, 0015	Nov92
Honolulu	KVM70	**9982.5**	24hr	10	1150,2350	May97
Honolulu	KVM70	**11090**	24hr	10	1150,2350	May97
Honolulu	KVM70	**16135**	24hr	10	1150,2350	May97
Honolulu	KVM70	**23331.5**	24hr	10	1150,2350	May97

*US Navy stations at Guam and Pearl Harbour
are difficult to receive using normal SSB equipment.*

For full Fax Skeds of Australia and New Zealand refer to last section of book

METSERVICE
A world of valuable information

Technical information for NZ METSERVICE Radio Facsimile Station

Call sign:	**ZKLF**
Name :	**AUCKLAND**
Location:	**Auckland Airport**
Correspondence Address	PO Box 722, Wellington, New Zealand
Intended reception area:	30° North to 60° South 140° East to 120° West
Published Frequencies (kHz) (0000-2400 UTC)	**5807** **9459** **13550.5** **16340.1**

Tune to published frequencies and switch to single (upper) sideband.
Even when no maps are being sent a carrier tone is available for tuning.

Power of Transmitters:	5 kW
Class of emission	FSK (Frequency shift keying)
Bandwidth	BLACK = -400Hz
Index of Co-operation	576
Scanning line density*	3.9 lines per mm (100 lines per inch)
Scanning Frequency	120 revolutions per minute (lines per minute)
Scan rate * (drum speed)	120 rpm
Start Tone	Carrier modulated by 300Hz for five seconds
Phasing Signal	BLACK signal interrupted by one WHITE phasing pulse per line, transmitted for thirty Seconds before transmission of each chart.
Stop Tone	Carrier modulated by 450 Hz for 5 seconds followed by 10 seconds of BLACK signal.
Schedule Broadcast	0445—0500 and 1645—1700 UTC

Timing of transmissions is computer controlled.
*Scanning is no longer done on a rotating drum, it is now computer generated.

Decode of abbreviations used on schedule
All times are UTC (Co-ordinated Universal Time)

Map Areas

NZ	New Zealand
TNZ	Tasman Sea and New Zealand
NREG	Aviation area map from New Zealand to Southern Cooks
NPAC	Aviation area map from New Zealand to North America (Los Angelus)
ASIA	Aviation area map from New Zealand to Japan
EPAC	Aviation area map from New Zealand to South America.
SWP	South West Pacific for surface maps from Australia to 120West
SPC	South Pacific for surface maps from Australia to Cape Horn

MSL (Mean Sea Level) Maps Products

ANAL	Analysis (based on observations for a given UTC time)
PROG	Prognosis = expected future value.

Prognosis period is quoted as number of hours after analysis time, e.g. H30 means 30 hours after analysis.

MSL ANAL MAPS

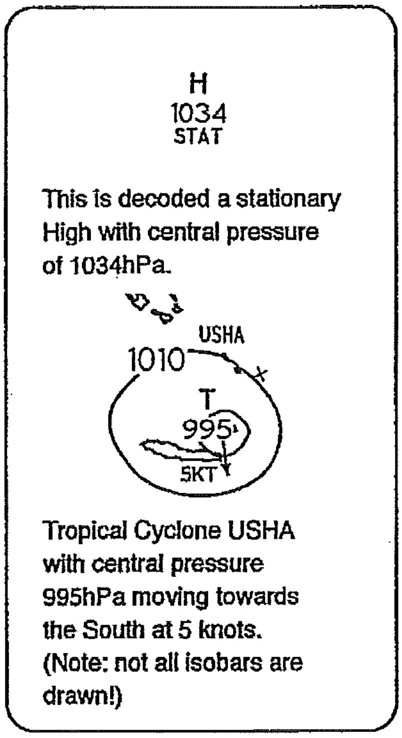
For sailing the best weather maps are the **MSL** maps (surface level). An **ANAL** (analysis) map *gives you a good idea of what weather systems are around.* It is based on all observations (including land stations, ship and drifting buoy reports, satellite images of clouds, and weather radar images of rain) collected for a set nominal UTC time. By the time you get an ANAL, the base time will be several hours ago.

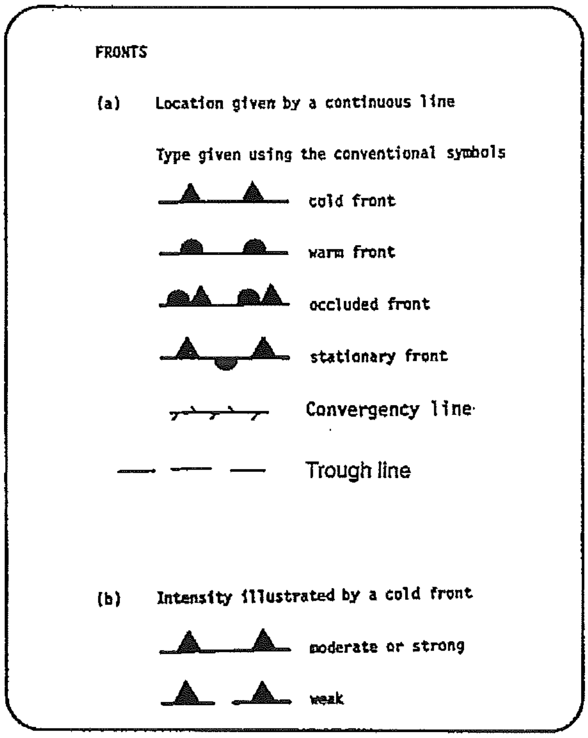
METSERVICE offers three areas of analysis
TNZ (Tasman Sea and NZ)–six hourly
SWP(Southwest Pacific)–12 hourly
SPC (South Pacific from Australia to the Horn) –12 hourly (This is a re-transmission of a chart from Australia)

Symbols

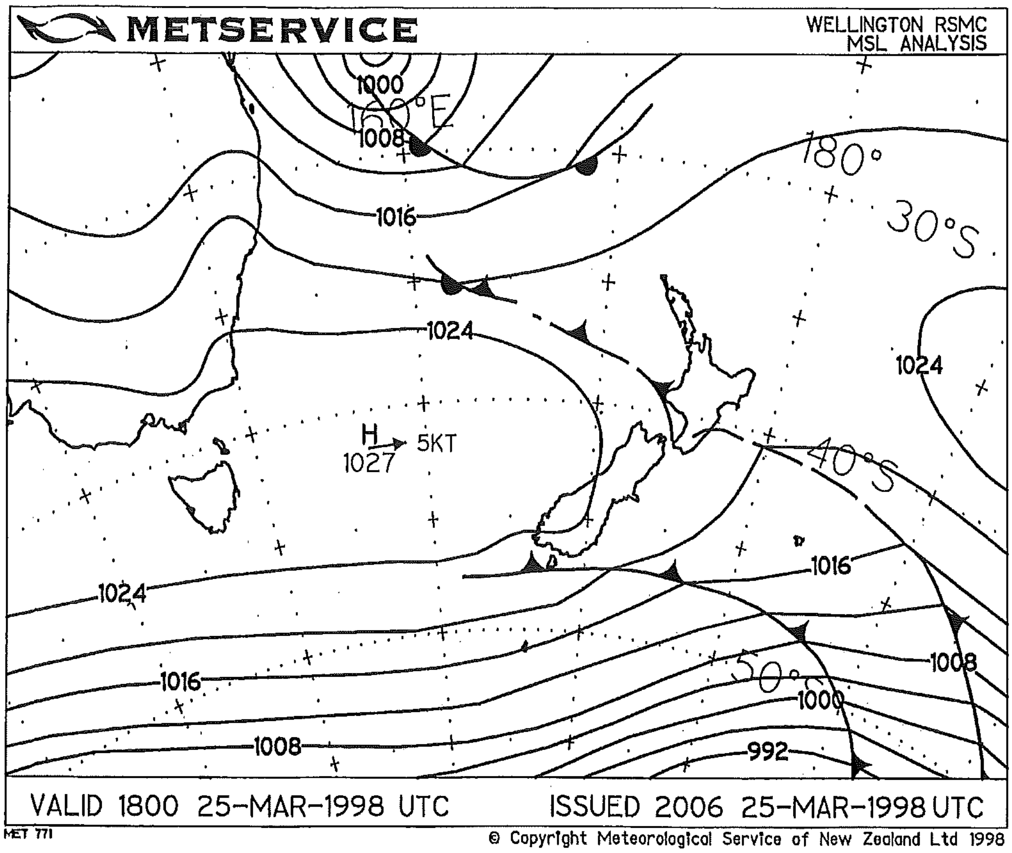
Pressure system symbols used are **H** for High, **L** for Low and **T** for Tropical Cyclone. Intensity of central pressure is given in whole hectoPascals.
Position of centre is midway between the pressure symbol and the pressure intensity value. Movement is towards the arrowhead, and speed of movement is given in figures near the arrowhead.

STAT means stationary.

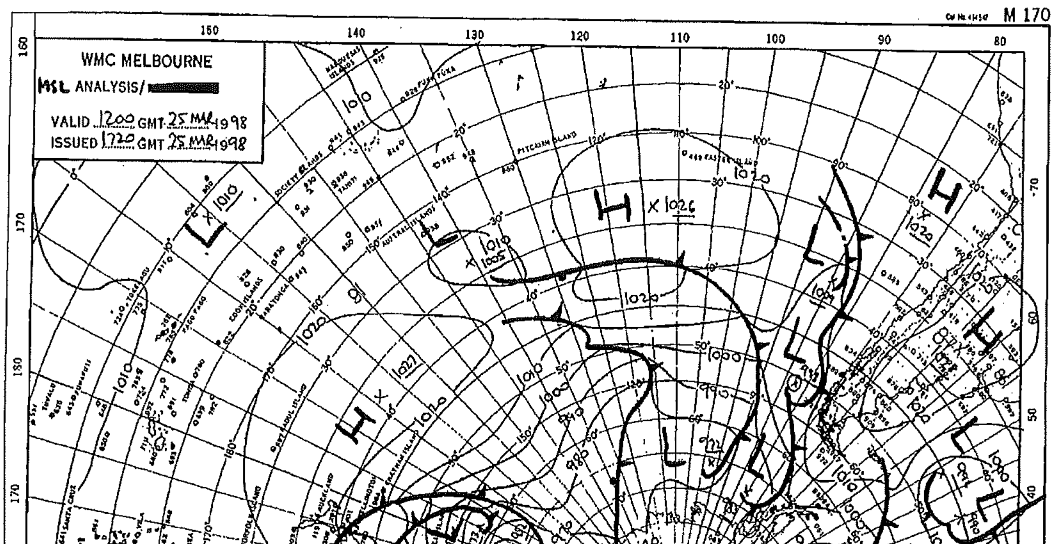




EXAMPLE OF MSL ANALYSIS (ANAL) TNZ



EXAMPLE OF MSL ANALYSIS (ANAL) SPC

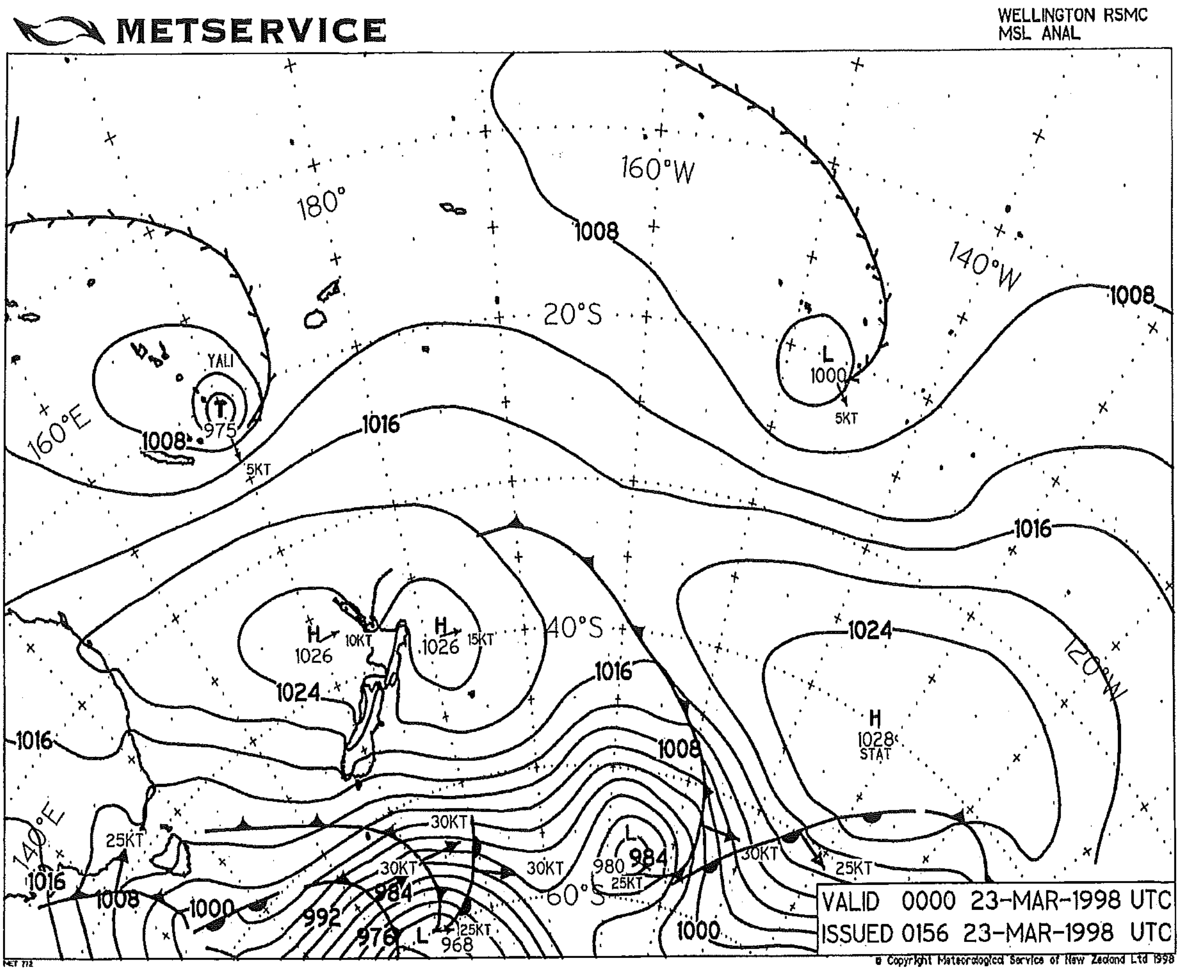


MSL PROG

A **PROG** (prognosis) map *helps explain what weather systems are expected to do.* It is a drawing of the best construction of the position of isobars and fronts at a set future time. This construction is based on manual interpretation of all available data, including three global weather computer models and two local models. On METSERVICE NZ weather fax, these only cover one area: SWP, the South-west Pacific, and are issued twice daily.

An ANAL and a PROG combined together give the best idea of the changing weather around you.

EXAMPLE OF MSL PROG SWP H30



SIG WX maps

These maps, available from http://weather.noaa.gov/fax/ and from Australian weather fax, highlight areas of weather of importance to jet aircraft. They can also help a cruising sailor in the tropics for they show the location of areas of thundery showers—places to avoid if you want sunshine, but places to find squalls and help break through the doldrums. In the tropics these areas change slowly, so you need not call up every Sig. Wx. map.

The only clouds that upset jet aircraft are those within active thunderstorm areas, and these are referred to as CB (for cumulonimbus). Areas that have isolated thundery showers are NOT depicted because it is assumed that if the thundery showers are not embedded in (enclosed or contained within) other clouds then they can be clearly seen and easily avoided.

Cloud areas depicted are

ISOL EMBD CB Isolated individual CB clouds which are embedded (contained) in the depicted area of other layered cloud.

OCNL EMBD CB. Occasional well-separated CB clouds which are embedded (contained) in the depicted area of other layered cloud.

FREQ CB Frequent CB clouds with little or no separation.

FREQ EMBD CB Frequent CB clouds with little or no separation which are embedded (contained) in the depicted area of other layered cloud.

Layers are given with top over base in units called FLs (Flying levels).

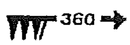
E.g.: 320 =top at 32,000 ft.
260 =base at 26,000 ft.

XXX is used when the top or base is expected to lie outside the layer of atmosphere to which the chart refers.

E.g. : 350 or XXX .
XXX 260

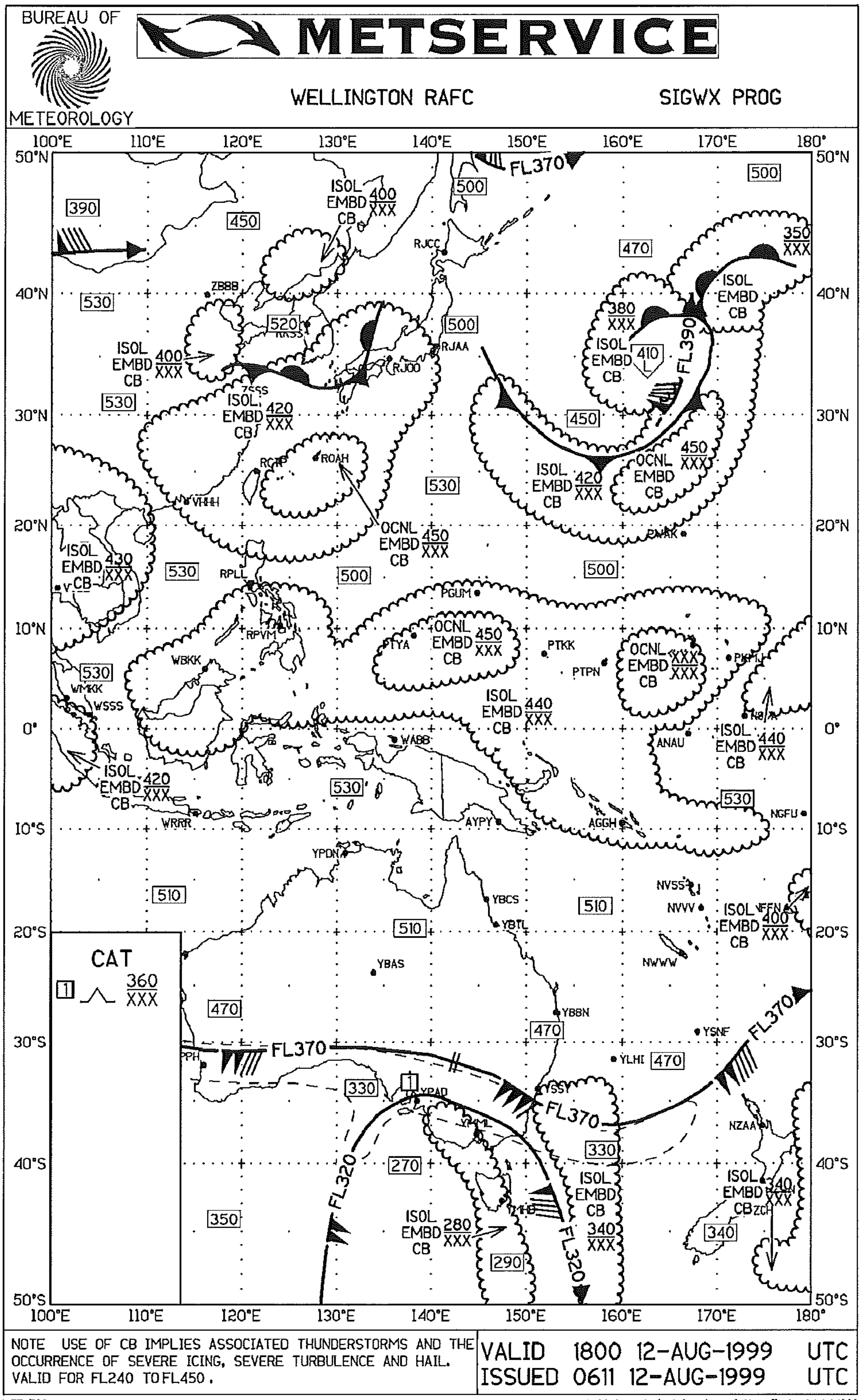
Other symbols on SIG WX maps

Clear Air Turbulence:

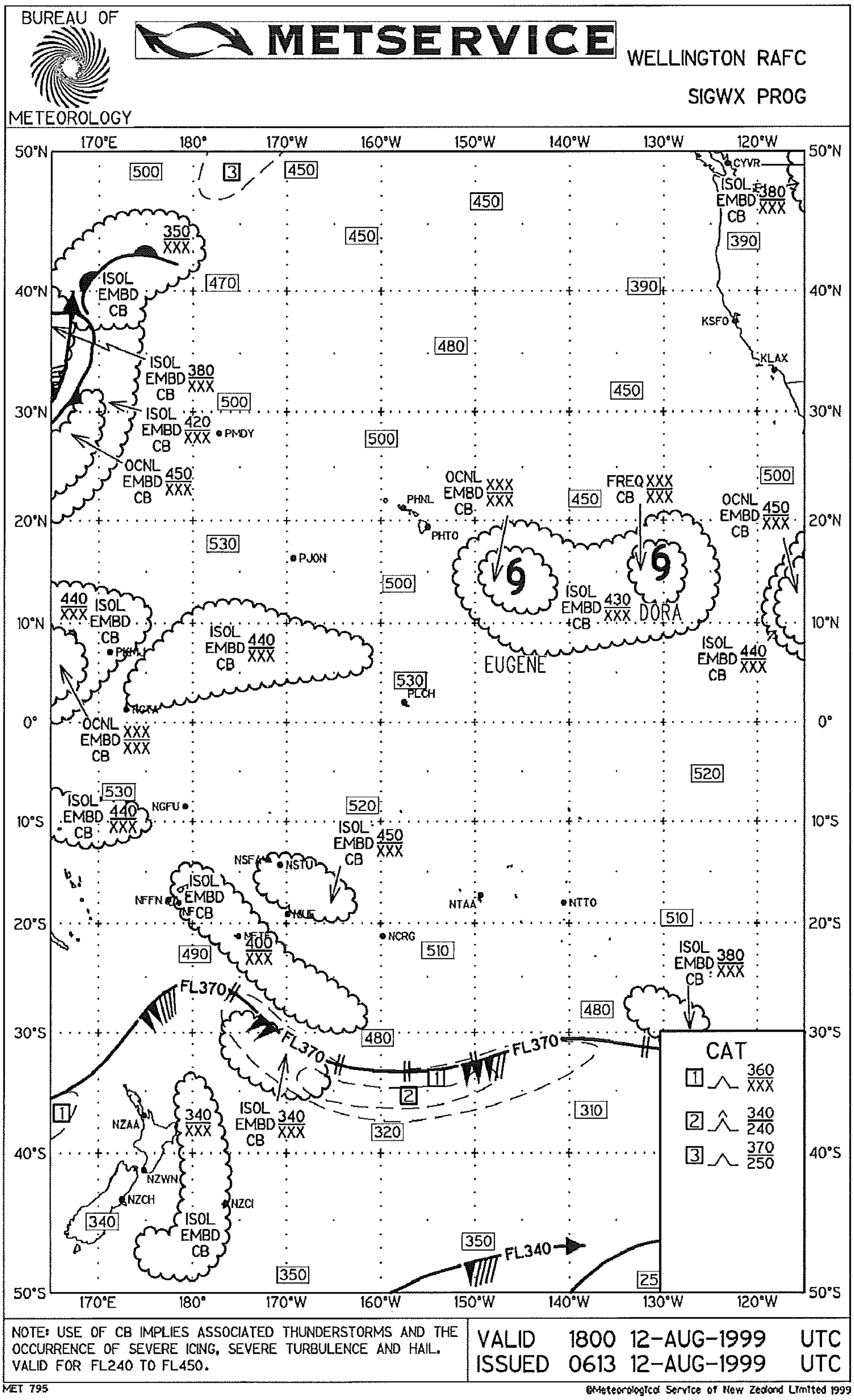
CAT	(appears near Jetstreams and does not on radar).
	Moderate turbulence in cloud or clear air.
	Severe turbulence in cloud or clear air.
	Moderate airframe icing
	Severe airframe icing
[1]	Single digit numbers refers to notes on the side of the map.
[530]	Triple digit numbers give TROPOPAUSE height in FL(e.g.:530 = 53,000ft)
	Boundary of area of cloud containing significant weather.
-----	Boundary of area of Clear Air Turbulence
	Axis of Jetstream with speed and FL of maximum wind. Each pennant is worth 50 knots, Each barb, 10kt.
	Tropical cyclone with maximum sustained surface winds in the range 34 to 63 knots.
	Tropical cyclone with maximum sustained surface winds 64 knots or more.
	Volcanic eruption ash cloud. Volcano is at dot.

SIG WX (Significant weather for flying) maps are issued for areas ASIA, NREG and NPAC several times a day

EXAMPLE OF SIGWX PROG (future map) for area ASIA



EXAMPLE OF SIGWX PROG AREA NPAC



Reading Upper Air Weather Maps

The main weather map most sailors are familiar with is the Mean Sea Level map. After all, we sail on the sea, not in the air, so this map is the most appropriate. Clouds, however, sail in the sky and they are the best tracers of the changing weather. A lot of the weather maps now available from weather-fax or from http://weather.noaa.gov/fax/ are aimed at aviation and concentrate on the "upper air". Here are a few pages of notes on how to get the best out of these maps.

Ten tips on how to read the 500hPa weather map.

What is it?

The 500hPa map shows the HEIGHT ABOVE MEAN SEA LEVEL of the 500-hectoPascal surface—namely, where the pressure is exactly 500 hectoPascals. This height is about 5 km above the poles and 6 km above the equator, so it is around 18,000 feet aloft. Since most upper-air maps are used for flight planning, they simply give a grid of wind speed and air temperatures. Some still show the contour lines with numbers such as 550, meaning 550 decametres or 5500 metres or 5.5 km.

2. Steering

The wind flow at 500hPa is, to a first approximation, a steering field for the features on the surface weather map. Think of the Highs, Lows and fronts shown on the surface map as being pushed about by the 500hPa winds.
Check out the wind flow at 500hPa above a surface high, H. If the wind - flow is light, then H can be relied of to be slow moving. If there is a steady 500hPa flow above H, then H will be carried away by this flow and will be gone tomorrow.
The stronger the winds are, the greater must be the temperature change across this wind flow and thus the heavier the resulting rainfall.

3. The terms we use

An upper ridge: When the winds are turning around an area of higher contour values we name this area as an upper ridge. Upper means we are dealing with conditions aloft; ridge comes from the idea of a hill on a contour map. On a grid map, an upper ridge is shown by the changing direction of the wind barbs—counter-clockwise in the Southern Hemisphere and clockwise in the Northern Hemisphere. Upper ridges actually look like hills on Northern Hemisphere weather maps which are oriented with north on top. The wind flow around an upper ridge is called ANTICYCLONIC CURVED or simply ANTICYCLONIC.

Ridge axis: the midriff of an upper ridge.

An upper trough: The opposite of an upper ridge; So this is an area where the wind barbs are bent in a clockwise fashion in the southern hemisphere, or in a counter-clockwise direction in the northern hemisphere. the wind flow around an upper trough is called CYCLONICALLY CURVED or simply CYCLONIC.

Trough axis: the midriff of an upper trough.

A Cut-off Upper Low: An area where the wind barbs complete a clockwise circle in the Southern Hemisphere, or a counter-clockwise circle in the Northern Hemisphere. These are nasty areas. See tip number 9.

Long waves: The wind flow around the globe in the upper air is generally from west to east, but it bobs north and south as well in a roller-coaster fashion. These roller-coaster waves keep changing but at any instant in time are good indicators as to which way energy (from the sun) is being distributed around the planetary weather systems. Looking at an upper air map you can usually identify areas which are cyclonic and other areas which and anticyclonic. Often these areas define the up and down areas of a roller-coaster, which only has four (or fewer) humps around the globe. These are called Long waves, and are stable, slow-moving features which help fix the surface weather pattern for several weeks.

Short waves: Closer humps on the roller-coaster (you can fit more than four round the globe).

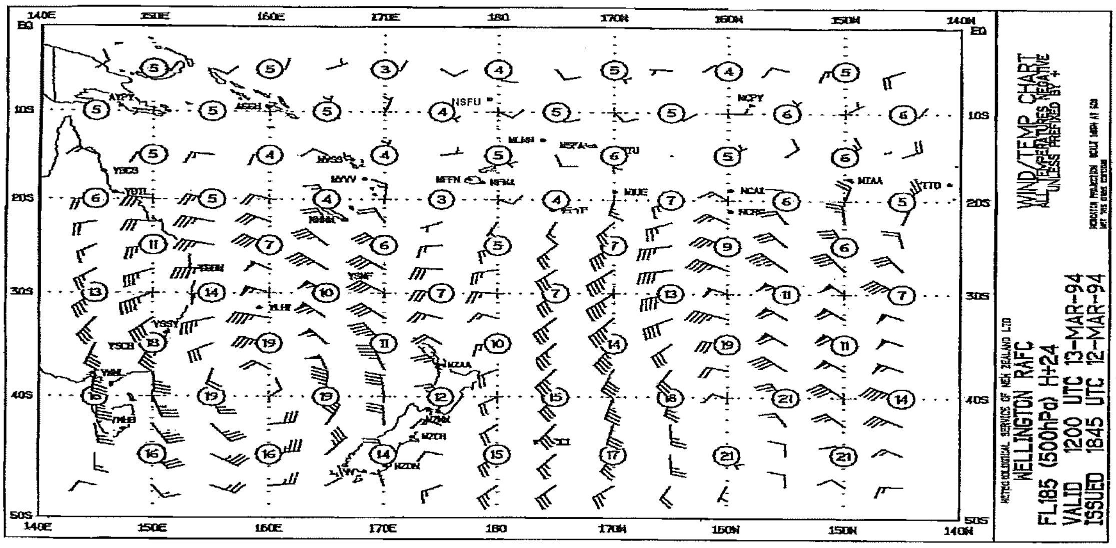
Surface lows are given a boost when a short wave trough tracks along the roller-coaster of a long wave trough, but usually these short waves are travelling quickly so the boost normally only lasts for a day.

4. Types of flow

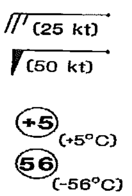
Zonal flow: Most of the wind goes from west to east (along the zonal latitude lines), without much bobbing north or south. This pattern is typical of spring—fast movement of short wave features, and not much time for things to develop over a large area.

Meridional: Many of the wind barbs go north or south (along the meridians of longitude). This flow pattern sets up zones of strongly contrasting temperature, allowing good-sized

EXAMPLE OF 500hPa PROG NREG H24



Decode of symbols



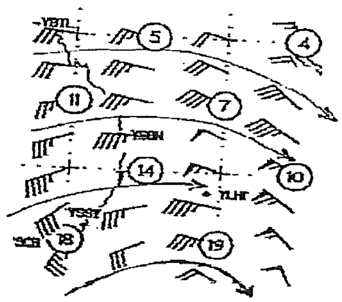
Wind direction and speed is indicated by an arrow with barbs and shaded pennants
One barb = 10 kt
One shaded pennant = 50 kt

Temperatures in degrees Celsius are indicated by figures inside circles
All temperatures are negative unless prefixed by a plus (+) sign

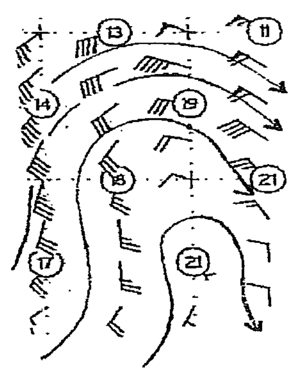
cyclones to develop. Indicates plenty of energy available for rain.

Blocked: Also called the Omega pattern because the wind flow takes the shape of the capital Greek letter omega to get around this feature. A large area of ANTICYCLONICALLY curved air sits in the heart of the block, bringing a long period of below normal rainfall there. Weather systems pile into each other on the upwind (western) side of the block and have to slowly rotate around each other as they go round the blockage. This brings wetter than normal conditions there (New Zealand recognises this as MMP = much more precipitation). The Red Spot on Jupiter is a good example of a block lasting decades. On Earth it takes weeks, sometimes months for a block to break down.

A weak surface front is usually accompanied by an upper trough shaped like this....



An active surface front has a prominent upper trough behind it...



5. Contour numbers (where available)

To a first approximation, the lower the contour numbers the colder the air (cold air packs together more densely than warm air). On the grid maps, air temperatures are given and these can be used to work out trouble spots.

Any area that has an upper temperature colder than places immediately west or east is a trouble spot. Rising air in this place will cool quickly and turn into clouds and showers more than place immediately west or east. The reverse also is true—a warm spot is usually a spot where clouds evaporate.

6. Curvature is the key word.

When the upper wind flow is curved, interesting things are happening in the atmosphere and exciting adventurous weather is the result. Cyclonic curvature helps showers and thunderstorms to develop. Stronger than normal cyclonic curvature helps hails and maybe even tornadoes and waterspouts to develop.

Many times in summer, all that appears on the surface map is a feeble-looking high-pressure system, H, perhaps offering a fine day with light winds. However, if there is a short-wave trough or some cyclonic curvature on the 500hPa map above H, then the air is all set to be triggered by morning surface warming of land areas to produce nasty afternoon coastal thunderstorms, EVEN THOUGH THERE ARE NO FRONTS ON THE SURFACE WEATHER MAP.

7. The westward tilt

In both hemispheres the normal state is for weather systems to tilt westwards with height. Cold air arrives first at surface level and later at higher levels, so the upper trough is well to the WEST of the surface trough / cold front. It also means the surface low centre (L) is normally midway between an upper ridge (on the eastern flank of the L) and an upper trough (on the western flank of the L). The behaviour of L is determined by this upper ridge and, more importantly, by that upper trough.

When the upper trough starts to catch-up with L (and the westward tilt straightens up) the atmosphere becomes dynamically unstable and L deepens. This intensification moves upwards helping the upper trough to become a cut-off Low.

8. Vertical Stacking

If the upper trough does catch up with L and lies vertically above it, then L has matured. The air has become homogenous and well mixed, so there is little chance of any further intensification. The steering field is also reduced to a quasi-stationary circular motion, so that L becomes "slow-moving"

9 A cut-off upper low can be nasty.

It has built a large area of air with temperatures colder than its surroundings.

In the example, checkout the -19C in the Tasman Sea compared with -14C over the South Island. The central air is UNSTABLE and thundery showers can grow at any time (day or night), even in places where the surface weather map shows NO FRONTS.

With the cut-off upper low, the steering field of surface features is reduced to a slow circular motion. This means that the weather remains unsettled for several days.

10 Conditions to make a <u>BOMB</u>

A bomb is a surface low which drops its central pressure 24 hPa in 24 hours (when corrected to a latitude of 60°).

• **<u>Take moist air...</u>** A deep juicy flow coming from out of tropics on the western flank of a surface high-pressure area is ideal.

• **<u>make a zone of strongly contrasting temperature...</u>** Usually found near a good-looking upper trough. Can be enhanced if a new surface high is forming in the Polar Regions and tosses cold air ahead of it. Also enhanced briefly as a short wave upper trough of the right speed, intensity and timing makes its wave around the roller coast of a long wave trough.

•**<u>...and blow hard.</u>** If there is a jetstream at the 200 to 300hPa level of the atmosphere, it can act like wind at the top of a chimney, removing air faster than it is supplied and so drawing air upwards against gravity then venting it away. As this air gets blown away, the total weight of the air in the chimney becomes less, and so the air pressure measured at the surface drops.