

# Weather for the Yachtsman

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The following is a series of lectures I have given to yachties with the aim to provide a bit of information on weather terminology, definitions, rules of thumb and the use of Grib files for forecasting. These papers are not technical and are designed to help the user wade through the sometimes confusing terminology from various forecasting sources and also to provide some hints as to how to best use data obtained from the Grib files.

## CONFUSING TERMINOLOGY

There is a confusing array of terms describing cloudy and rainy weather. We're confronted with Fronts, Troughs, Convergence Zones, Shear lines and Instability Lines. Let's make some sense of them.

A TROUGH is simply, and *technically*, an elongated area of relatively low pressure. A trough is typically found between two Highs, but can also be found in a Depression or Low, or even in a ridge of High pressure. If you draw a line down the center line of a trough the pressure on either side of the line will be higher, thus the wind wants to flow 'downhill' or to the trough axis. Here the air converges and rises to form cloud and rain. In *practice* the word Trough is used when there is NO temperature differential on either side of the centerline. And this is the main difference between a Trough and a Front. In practice the use of the word FRONT means a definite temperature discontinuity across it. Technically a Front is defined as the interface between two air masses of different density (temperature or moisture). Both will have a wind shift across their axis.

### What forms a Trough?

Apart from the simple example of a trough found between two Highs, a trough can develop when there is upper air forcing. The most common cause of a trough in the sub-tropics is the jet stream. In a jet stream we often find a jet max or an oval area of very high wind. This jet max creates an upward motion felt on the surface, thus surface pressure falls to create a trough. Sometimes in a ridge extending into the tropics we see a polar dip, or inverted trough, in the isobars. (the isobars turn southward or polar, and then curve back northward, or equatorward, before continuing their anticyclonic rotation). This is a warning because the 'dip' has the potential to develop into a Low. Again it's usually a jet max that initiates this. Alternately, however, an extension of an upper level trough towards the equator can act like the jet max by also causing surface pressure to drop, creating a surface trough.

The second sort of trough we see is when a stationary front lies more or less east/west. At the beginning there is a temperature difference across the front but as it slows down forecasters call it a QUASI-STATIONARY FRONT. And after a while the

temperatures become more uniform and technically the feature is no longer a front. Some forecasters at this point like to call it a 'SHEAR LINE', and some call it a TROUGH.

Thirdly, a trough can develop in the cold air behind a cold front in the sub-tropics. After you're through the front and experience the normal backing of the wind you may notice the wind strangely veering slightly. This is a prelude to a secondary trough and when it passes the wind backs again. Unfortunately there can be multiple troughs behind the original cold front. Secondary troughs are quite common in the SW Pacific and are caused by a jet max.

Lastly we occasionally come upon an INSTABILITY LINE. This is a term used in the Tropics for an isolated small band of clouds which have the potential to develop into a tropical disturbance or simply cloud and rain. Its causes can be varied and complex.

So let's summarize the terminology quite commonly seen on various Met Reports:

1. Cold Front. A band of cloud, showers and potentially violent weather with a definite temperature difference on each side.
2. Surface Trough. A line or band of cloud and showers where the temperature is similar on both sides.
3. Quasi-stationary Front. A cold front which is moving less than 5 knots. A definite temperature difference exists on both sides.
4. Shear Line. Another name for a Quasi-stationary front in the tropics.
5. Convergence Zone. In the tropics this is a line or band of cloud and showers where winds of different directions and speeds merge together. It is non-frontal which means no temperature difference exists on either side.
6. Instability Line. A non-frontal band of cloud and showers in the tropics.

To explain a little further, the Cold Front, Surface Trough, and Quasi-stationary front/ Shear line are usually formed and sustained by upper level forcing. Forcing means there is an upper level feature causing a drop in surface pressure. Very simplistically think of a huge vacuum cleaner at approximately 40,000 feet pulling up surface air. As opposed to this, a Convergence Zone is formed by surface flow from different directions and may be sustained and enhanced in the long term by upper level flow allowing the rising air to vent. This is not accomplished by the previously mentioned 'vacuum cleaner' effect, but instead think of an efficient chimney sustaining a fireplace. This also happens at around 40,000 feet by strong air flow at that level 'pulling' the rising air along with it.

## CONVERGENCE ZONES

We've previously discussed in an earlier lecture Troughs and Quasi-stationary fronts but the most prevalent and wide spread linear areas of cloud in the tropics are Convergence Zones.

A Convergence Zone is caused when two air streams bump into each other. The air has no choice but to go up which results in Cloud and Rain. This process can go on for days and then suddenly cease to exist or shift location.

Most of our listeners receive the 'grib' files and can usually receive weather faxes. These are two modes to identify convergence zones in the tropics. For simplicity let's define 'tropics' as the area between the equator and 23 South or North.

When looking at the grib files carefully look at the wind arrows. When you see a linear area where the wind arrows are pointing toward one another, even if at a shallow angle you can bet this is an area of convergence.

If you receive the KVM streamline report you can identify convergence areas by the way the streamlines converge, again in a linear fashion. The stream lines are the actual direction that the wind is blowing but they do not denote wind velocity. In other words if the lines are close together do not assume the wind is strong. There is one tricky caveat in looking at streamlines. If the streams are converging but also speeding up, there may be no convergence at all. An analogy is picture two different 4 lane freeways merging together with no loss of lanes. The cars don't slow down, nor would the wind. Unfortunately you can't identify this nuance in the streamline report.

Another cause of a Convergence Zone is a process called Speed Convergence. This occurs when a strong flow of air moves into an area and slows down. The air piles up like cars at a toll booth. So up goes the air followed by cloud and rain. Surges in the tradewinds that result in speed convergence can come from the east side of strong Anticyclones. These surges of wind lack fronts but when they enter the Tropics they slow down and create a cloud line, or convergence zone. So be wary of Highs over 1030mb, as the feature passes to our south the resulting trade wind surge will usually create convergence. Look at your surface analysis and progs for these features.

Speed convergence can also occur when isobars are closer together to your east and wider at your location. The result of this is reflected in the grib files by looking again at the wind arrows. If for example, an easterly wind TO your east is 25 knots, but the arrows show your area to be 15 knots, then expect convergence.

Keep in mind that throughout the Tropics wind LOCALLY accelerates and decelerates usually without apparent cause, but often with significant effect. This can explain why a cloud cluster or band can suddenly appear one day and be gone the next.

Now convergence zones can be meek or they may be quite active. One thing that particularly makes them active is if we have a way to vent all this rising air. A strong flow at 200mb will accomplish this, but unless you can access the data on the internet you won't know about this level. If you have the ability to receive NOAA low altitude satellite imagery, such as SKY EYE, you can see strong upper level flow by the way the cloud tops stream away as streaky lines of cloud on the downstream side while the upstream side is relatively sharp.

And finally we'll mention the difference between a front and a tropical convergence zone. The CZ has no temperature difference across the feature, while the front does. And to complete the circle both may be considered troughs, because the strict definition of a trough is simply an elongated area of lower pressure.

Now, as is typical in life, people take liberties which may cause confusion. Some Nandi forecasters in particular call a cloud band a trough while another would call it a

convergence zone. Neither is technically wrong. So to simplify, what is called a trough at our tropical latitude should arise as an extension of a distant front that has or hasn't become detached from its parent Low, but has lost most of its temperature or density differential. And if the cloud bands' origin was not from a front, and there is no density difference on either side, and streamlines show directional convergence, then call it a CZ. This is a bit of a grey area and terminology can differ from forecast office to forecast office often driven as a function of popular jargon, and not by technical definitions.

## WHY IS IT SO CLOUDY IN VANUATU?

Well it's not confined to Vanuatu! Cruisers often experience a seemingly permanent cloud band from the New Guinea/ Solomons area through Vanuatu and often on toward Samoa and Fiji. The cloud band comes and goes but seems to be present more often than not. To help explain this consider the western Pacific as a "hot pool" where high sea surface temperatures help cause an "upwelling" of the atmosphere which in turn creates a convergence zone. The high sea surface temperatures are a function of course of the sun's intensity at low latitudes. As this water is driven westward by the trades it pools, and during normal to La Nina years the sea level is some 300mm higher in the western Pacific than it is near South America. The zone of cloud produced wanders back and forth, sometimes to the north, sometimes to the south. The cloud band is also helped along by the convergence of winds that originate in the South Pacific. To the north of the band the winds come from the semi-permanent High off to the east, near Peru, while to the south of the band the winds come from the traveling Highs as they traverse the Pacific from west to east. This zone is called the South Pacific Convergence Zone.

So what factors affect the zone?

First let's consider the MJO (Madden-Julien Oscillation), which is a wave oscillation traveling around the globe on an average of 40 days. The center of the pulse is an area of deep convection. It will activate the convergence zone.

Second is El Niño. During this event the pile of water in the western Pacific sloshes back to the east and weakens the semi-permanent High. This results in diminished easterly trades, and the convergence zone tends to form further east. So we have drier conditions in the Solomons, New Cal, Vanuatu, Fiji and Tonga. Conversely a strong La Nina enhances the zone.

Third are the troughs that are always in-between the traveling Highs. Let's include cold fronts here too. As these features approach the tropics they too will activate any existing convergence zone. The cold front, as it eventually tends to do, will lie more or less east-west and become quasi-stationary (moves less than 5 knots). At this point it is often referred to as a shear line.

Fourth we have trade wind surges. When a strong High (1030mb or so) pushes up a ridge into the tropics, the surge of accelerated air slows down, piles up, and creates cloud and rain. And again, the surge will activate an existing cloud band.

Fifth is an upper level trough extending up to tropical latitudes. It can cause surface convergence directly under upper divergent flow which lies east of the upper troughs axis.

Sixth is a Jet Max. These zones of very high upper winds can cause surface convergence underneath the equatorward entrance of the max.

Climate studies of “average cloudiness” in fact show a persistent maximum extending east-southeastward from New Guinea. The clouds are more extensive from Oct. to March. The summer months show the zone to be most active and often lie between surface east to north-easterlies to its north and south-easterlies to its south. These studies even include a climatological (present most of the stated period) Low just east of New Guinea. This is a prime area for Tropical Depressions.

In summary we’ve discussed several reasons and causes for a “cloudiness maximum”. We’ve defined the zone as the SPCZ. But in my view the SPCZ is an all encompassing, generic term and while it is technically correct to call a band of cloud a “branch of the SPCZ”, it may be better not to overwork the term. Most forecasting offices simply say CZ.

## MODELS ,THE GRIBS, AND THEIR LIMITATIONS IN FORECASTING

Weather computer models, or what we euphemistically call the ‘GRIBS’ are quite complex creatures. In this lecture we will look at what goes into making a model and also why it has limitations. In the next lecture we will discuss how to get the most from the gribs.

Data from all over the world is received at 00Z and 12Z at all computer modeling facilities. This includes data from weather balloons, plane and ship reports, Airport reports, Cloud Drift Winds from satellites, data from other models, satellite imagery and especially scatterometer data which show actual surface winds. There is more but this gives you an idea. All of this information is plugged into the computer in a process called initialization. The computer takes this data, plugs it into complex formulas and crunches numbers. It starts with the information at time zero, then forecasts to 1 minute, then two minutes, on and on to maybe 14 days. It takes about 2 hours for this process.

What can cause the output to be in error? The obvious is that if any input data is bogus the entire model output may be compromised. The equations themselves have limitations. The models have biases. The model can suffer from convective feedback. An example of this is if a one off convective event becomes part of the initialization, the model could blow it out of proportion creating what was a small, one time event, to projecting a big Low. A model like the GFS has great resolution, 30 miles, but useful observations that are part of the model input may be 300 or more miles apart, especially in the middle of the South West Pacific. So even though the observations may be accurate there are too many gaps, and a gap is the same as an inaccuracy which is compounded as the model steps forward in time. And then there is the

infamous Chaos Theory. This is the idea that a butterfly flapping wings a thousand miles away can cause a storm locally. The thing is, the atmosphere is not linear. A good forecaster will compare the 00hour output of the model run to the actual conditions in his or her area. If the initial model output is not in agreement, then the whole output is in question, and you may reject the model. We don't have that luxury, which is why it is important to look at other sources of weather information.. And there are a myriad of models. There are global models, mesoscale models for small areas, nested models where one model is incorporated into another, and ensemble models. This last one is valuable to a forecaster. What this model does is tweak each initial condition 16 or more times just a wee bit so that there are 16 model outputs for each forecast period. Say we are looking at the shape and location of isobars around a low and a high. The model, with each tweak, lays an isobaric pattern on top of the next, like a layer cake. If, for say day five, the isobars lay on top of each other in a matching fashion, that forecast period should be superb. If they don't and the isobars lines look like a dish of spaghetti, then that model won't do so well for that time.

To appreciate how today's operational forecasters work let's briefly take a look at the New Zealand Met Service. Each morning a meeting is chaired by a lead forecaster in a room with maybe 10 forecasters present, each with three computer screens in front of them. The forecasters represent Aviation, Marine and Farming interests. On each screen is model output from three different models. The lead forecaster offers his opinion and projects the models on a big movie size screen in the room. Satellite imagery is also overlayed on the various models. The ideal goal is to see at least two models that agree, three would be better. Other real time data is examined as well. He goes around the room for opinions and the synopsis and forecast is tweaked. Once everyone agrees, the computer draws the new map and forecasts, and off to press they go. The process is a bit more involved than just described, but you get the idea. Observations I made after a day at the Guam NOAA weather office show their procedures were quite similar.

So here we are, dreamy cruisers, with one grib file and little else, thinking we can forecast with the best of them. Inevitably some of us will curse the grib files when they're wrong. This is human nature but a model output is just an idea based on incomplete input, using equations of the atmosphere which are not perfect. It takes much more than a model to do a proper forecast. But, now you've seen what's involved you'll hopefully be a wee bit kinder to the grib file with its many faults; just like we have. The two models that are easily available to those with a computer and sailmail/winlink/or other, are the GFS and NOGAPS. The latter is a US Navy model and both are global. Both models have biases. The GFS is a model that is quick to predict a future event but tends to overwork Depressions. In other words it has a tendency to make them deeper and moves them faster than what really may happen. This model amplifies meridional flow and creates Lows that may not occur. Meridional flow means wind that tends to flow in exaggerated waves, running more or less north to south then vice versa, as opposed to zonal flow, which are more shallow waves moving quickly west to east. Meridional flow is a condition in which Lows can form quite readily. This is to say in a nut shell GFS creates more false alarms than

NOGAPS. It however, is a very good model that is getting better all the time and even now enjoys a high skill score.

The NOGAPS model is more conservative than GFS. It tends however to under-forecast developing Lows and understate their wind. It tends to merge a complex Low into one low center. A complex Low is one with two or more Low centers, a common situation in the New Zealand area. Also note that this model aims strongly at cloud prediction because of obvious aviation concerns. This means it should do a better job of predicting convection. More the pity then, that saildocs doesn't offer the rain feature like they do for GFS.

So, in summary and at this date, view the GFS as the aggressive model and NOGAPS the conservative model. If you are planning a passage in the South Pacific it is a good idea for you to get the GFS and listen to the RAG for the NOGAPS. Compare the two, if they're reasonably close then the forecast stands a good chance to be good.

Whichever model you use, look for run to run consistency. The second run could have a feature disappear and then reappear on the third. Stay the course until two consecutive runs show a new scenario.

In terms of reliability, models are getting better and better. Projections out to three days are generally good and five days are O.K. After that, use the model for long range planning- but as an idea rather than something you take to the bank.

## HOW TO MAKE THE MOST OF THE GRIBS

In the previous talk we discussed computer models, their biases, and how forecasts are professionally made. In this session we'll discuss the practical use of the GRIB FILES which is the term cruisers use for the model output commonly obtained from the HF Radio, modem and computer. At this time many cruisers use winlink or sailmail.

It's best to look at Grib winds as a mean with perhaps a 5 knot range. For example if the grib forecasts 20 knots, think in terms of 15 to 25 knots. And over the open ocean gusts can be, and often are, 50% higher. So the 20 knot forecast can involve 30 knot gusts. The main reason for taking this view is the fact that isobar spacing, which determines wind, is quite variable.

Remember that the wind direction is True. This is a common trap as many of us like to think in terms of compass directions.

When ordering the Grib attempts to obtain either the 00Z or 12Z output. These are the times when the model output is initialized by actual conditions. The 06Z and 18Z output uses model projections for initialization and will generally not be as accurate as the 00 or 12Z. These times are termed mid-point forecasts.

When you are passage planning try to create the largest possible map size. If you are sailing from say Tonga to New Zealand use 15S to 50S and 150E to about 5 degrees east of your location. This is important as you need to see the formation and progression of Highs and Lows. Minimize the file size by changing the default 2x2 degree grid to 3x3 degrees.

Work the Grib backwards in passage planning. Figure your estimated Date of Arrival and push the grib out to that date. Look what you're up against and what the weather is forecasted to be on arrival.

Look carefully at the wind arrows. Are they directionally converging? If so, expect convection, which means cloud and precipitation. Are they forecasting stronger wind not far from your location? If the stronger wind is aimed your way expect convection caused by speed convergence. Therefore pay attention to the Anticyclones. If the central pressure is near 1030 expect strong winds as a result of the squash of isobars in the tradewinds. When the wind finally gets to you it's called a trade wind surge, of which the common result is convergence. On the other hand if it's been cloudy with precipitation caused by speed convergence at your location, are the winds forecast to be stronger downstream from you, and from the same direction? If so, clearing may be in the offing.

Find the Highs and Lows by the circulation patterns. In the South Pacific Highs will have the wind arrows in a counterclockwise pattern while in Lows they will have a clockwise pattern. If you are obtaining the grib from saildocs you may note a proliferation of H's and L's. You might think this means a High or Low, but it doesn't, and is a result of the saildocs software. The software compares the surface pressure at a point with eight neighbors, and if it is the highest point in the neighborhood it puts an H. In reverse for an L. True model output doesn't denote Highs or Low so find out yourself based on the circulation pattern. And pressure isn't necessarily a guide. Some think any pressure above 1014mb is a High and less a Low, but this simply is not the case.

Find Fronts by the 'kinks' in the isobars. If you get GFS use the 'Rain' feature which shows forecasted areas of precipitation. The precipitation zone will show the cold front. As an aside, the zone will also be a result of troughs, convergence zones, or simply cloud clusters. Fronts delineated in a Grib take up a larger amount of width than is reality. To help with recognizing fronts they will usually be found between the Low center, and the west side of the High to the east of the Low. The wind arrows will show directional convergence. By this is meant that on either side of the fronts axis, the wind arrows tend to point at one another, sometimes at a sharp angle, sometimes at a shallow angle.

Often in the SW Pacific a Low will have multiple troughs. These are often found to the left of a cold front as you are looking at the chart. If the grib is accurate you can see a change in wind direction across the trough. This change may be very subtle, and oftentimes the grib will miss it. This all takes a bit of practice, so to gain experience, use the New Zealand surface analysis and the grib for the same time period. Eventually you will recognize the patterns. Sometimes you will not see a feature on the grib that the New Zealand Met Analysis shows. By now you should realize that the human input is at work. One of the best ways to learn about wind flow about a cold front or trough is to get the KVM streamline report. Because streamlines are the actual wind flow, you will very quickly see the flow dynamics about a front, a CZ, or trough.

As an aside, it's a common notion to think that air flowing around a Low, with associated cold front, just goes round and round. It's easy to get this impression because the isobars form imperfect circles around the low center. The fact is, the air



on one side of the front is not the same air as on the other side. The 'other side' air is really coming from a High and is warmer. When the two flows meet at the front, they don't mix, they clash. The warmer side is pushed up and the colder side bulldozes its way onward. However in a tropical cyclone the wind indeed goes round and round; and it does the same in an occluded Low.

Never expect the grib to be accurate in wind direction, strength, or precipitation, near Islands or atolls. The 'grid' size of the model is often too large to take into account orographics. And perhaps more importantly the grib may not pick up very small features. For instance the model could potentially miss a tropical cyclone altogether. Also the shape of a coastline and the effect of cliffs and other physical features can twist and compress pressure gradients which makes for difficult modeling. But the model can usually pick up broad wind shifts. If in a tropical anchorage pay close attention to these as you may find yourself at an unsafe lee shore. There are models that deal with small features, but they are not readily available to cruisers.

If you are in port and can access WIFI, there are many other models to help you plan passages. including satellite imagery. Some people subscribe to Buoy Weather which is a nice pay service that also offers some of the products via HF Radio. They offer what seems to be an alternate wind model, called WW3. Be aware that this model is really a wave model and buoy weather uses the GFS winds to drive it. So while you think you may be getting a different wind source to compare with the GFS, you are not. On the internet the US Navy offers the WW3 as well, but they do not use GFS winds to drive it.

For you to obtain a better analysis for passage planning always make sure that you obtain whatever forecast charts that you can. Progs from New Zealand or Australia and Hawaii are important as they represent a forecaster's interpretation of perhaps the same model you are looking at. They will also help you understand what you are seeing on the Grib.

And finally, the most important thing to remember about models and the grib is that they are an idea based on incomplete input, using equations which are not perfect, and most important, they are NOT touched by a forecaster. You will be best served with viewing the grib as a source which tells you what MAY occur. But all this said, and given their increasing accuracy, they contribute to a safer and hopefully more comfortable passage or tropical anchorage.

## RULES OF THUMB

My not always faultless bits of information for cruisers

## ISOBARS

1. Where isobars are cyclonically curved, expect cloudiness and precipitation.
2. Anti- cyclonically curved isobars, expect dry weather.
3. If surface isobars are anti-cyclonically curved, but upper contours are cyclonically curved, clouds and precipitation may surprise you.

4. Isobars within 5 degrees of the equator are deceiving as wind may blow perpendicular to them instead of along them
5. Winds in the trades are not uniform as the isobars on a surface chart may indicate. You may have 25 knots and your mate 15 knots.
6. Winds don't follow isobars around land or coastline very well.
7. Remember that low latitudes produce higher winds than high latitudes for the same isobar spacing.
8. Anti cyclonic or straight isobars produce higher winds than cyclonic isobars of the same spacing.
9. Polar dips. Be wary of isobars dipping toward the pole and then turning back toward the equator. This is an area of cyclonic shear and means that a Low may possibly form.

## LOWS

1. Intensifying Lows tend to slow down and deflect more poleward, toward colder air.
2. The speed of a Low approximates the speed of the winds in the warm sector, and usually moves slower than the associated cold front.
3. Average speed of movement: Developing Low 30-35 knots, start of occlusion 20-25 knots, mature low 10-15 knots.
4. A surge of cold air moving in behind a cold front can turbo-charge the low, as can a surge of moist warm air ahead of the front. (Sydney-Hobart Race of a few years ago)
5. A Low moving eastward bumps into a blocking High. It can stall, do a loop, split, or move with the flow of the High in a polar direction.
6. In the winter cruising season don't be surprised by a secondary low forming in the relatively cold air behind the first low.
7. Following a very intense low, there is a probability of a second low forming on its equatorial side.
8. A secondary low can also form on an existing cold front.
9. Look at the isobars as they intersect the cold front on your synoptic chart. If they flow more or less parallel or at a slight angle the front will be slow moving and very wet. If they intersect the front at nearly right angles not only will the front be moving very fast, but expect prefrontal squalls. You may think the squall is the front as it can be very intense, but there is more coming. A gauge of the wind is how packed the isobars are.
10. The barometer usually rises along with a wind shift after a cold front. But if you experience a small shift of wind with little rise in barometric pressure, but then a drop in pressure there will be a secondary front coming.

## HIGHS

1. The sub-tropical ridge is where you find the travelling Highs. The latitude varies with the season, but is roughly North or South 30 degrees.
2. Travelling Highs tend toward the equator as they move east.
3. A Blocking High is a high that is generally broad, slow moving, or stationary. Sometimes they retrograde.
4. Any High with a central pressure over 1030 will have gale force winds on it's perimeter.
5. Always be wary of the west side of Highs. This is an area where the wind slows, bumps into itself (converges) and may form a Low or area of cloud and precipitation.
6. An intense slow moving High (usually intense Highs are slow moving) will tend to activate or intensify a Low or trough that is sitting equatorward of it.
7. If a cold front is nearing your position, look at the synoptic chart to your west. If the High following the front is intensifying then the cold front will intensify too.
8. Small Highs (in area) move faster than broad Highs.