

## WEATHER FORECASTING REVISITED

As sailors, the weather rules our lives. It determines everything from which harbor we anchor in and whether or not we sail on a particular day to which way we go around the world and which seasons we do it in. Living on a boat has transformed our casual and often indifferent relationship to weather ashore to an intimate and sometimes obsessive one afloat. In our first year aboard, much of what I thought I knew about weather forecasting proved overly simplistic; my conclusions were often inaccurate and sometimes misleading. After 50,000 nautical miles and five years of living with the weather, I have developed a more sophisticated understanding of how weather patterns translate into wind and wave conditions. To test this new understanding, we downloaded a total of over three years' worth of hourly data from four different buoys, two located on the east coast and two on the west, from the NDBC website at [www.ndbc.noaa.gov](http://www.ndbc.noaa.gov). The twenty periods of extended gale- or storm-force winds in the three-years of data can be used to illustrate three critical lessons, all of which I found counterintuitive compared to my shore-based assumptions. Yet we have seen these lessons confirmed again and again, in dozens of gales we have sat through at anchor and the few we've encountered at sea.

**The worst conditions generally occur on the rise of the barometer, not on the fall.** In my first few gales at sea, I heaved a sigh of relief when the barometer bottomed out and the wind stopped howling in the rigging. I soon learned not to assume the gale was over, but to use the time before the barometer began to rise again to prepare for worse weather than what we had already experienced.

In a 'symmetrical' storm system where the storm center passes directly over and the barometer rises as quickly as it falls, both wind speeds and wave heights on the rise of the barometer exceed those on the fall. In a recent case we experienced, the wind never even reached gale force while the barometer dropped despite successive hourly declines of from 2.3 to 4.5 millibars for ten hours straight. Wind speeds dropped below 20 knots for two hours when the barometer bottomed out, only to increase to storm-force winds on the first uptick. At the same time, the wind shifted by 180 degrees, from southeast to northwest. The sudden shift in conjunction with the storm-force winds caused the seas to exceed 20 feet within an hour of the wind shift.

When I read weather books before we left, words like "veer," "back," "build" and "diminish" left me picturing gradual changes over periods of several hours or days. But frontal

boundaries bring with them step function changes across all the variables illustrated. The pressure changes in huge leaps, the wind swings through 180 degrees and climbs 30 knots in minutes, and even the temperature can rise or fall by 30 or 40 degrees in a surprisingly short period of time. These sudden changes in wind direction and speed, in particular, create real dangers for sailboats whether at sea or anchor.

When wind speeds drop temporarily but large seas remain, too little sail area can leave a boat vulnerable to being rolled. When the wind begins to blow at gale- or storm-force from a completely different quarter, the waves build much more quickly than normal, and confused seas with large breaking waves often result. We know two boats rolled through 360 degrees in exactly these conditions. In both cases, they thought the worst was over and were lying ahull before putting up sail. When the gale-force winds resumed, they decided to ride it out lying ahull, and in the confused seas that followed a breaking wave rolled and dismasted them.

In recent case of this situation, the wind shift preceded the onset of strong winds by two hours, and in the other examples of this symmetrical, inverted bell-shaped curve in the buoy data, the wind shift gave several hours of warning as to its direction before it resumed blowing at gale- or storm-force. We have learned to use the period between the fall of the barometer and the rise to clean up the boat and ourselves, and prepare both for even stronger winds from the new wind direction indicated by the most recent wind shift. If offshore, we'll likely motor during this period to charge batteries and stabilize the boat in the lighter winds and still-large waves. When anchored, we use the lull to move to a different corner of the anchorage or to reset the anchor for the new wind direction.

**Wind shifts help predict the severity of weather on the rising barometer.** Based on what I'd read before we left, I thought this symmetrical, inverted bell-shaped curve would always appear on our barometer whenever we were experiencing heavy weather. Sayings like, "Long foretold, long past; short notice, soon past" reinforced the idea of symmetrical systems. After five years, we have learned that while the symmetrical barometer trace may be textbook, it isn't typical. Of the twenty periods of gale- or storm-force winds in the buoy data we downloaded, only four were roughly symmetrical, and that coincides well with our experiences.

Many factors affect the actual trace seen by a single-point observer during the passage of a storm system. These include the distance of the observer from the center of the low-pressure system, the center pressure of the disturbance, the existence of frontal troughs in association with

the low center, the speed at which the system is moving, the presence of secondary low pressure systems and the intensification or dissipation of the low. Any of these will result in a more complex and “messy” picture.

In another recent case, the barometer drops relatively rapidly, and when it bottoms out it stalls for 15 hours before climbing at about the same rate as it fell. Again, the highest wind speeds and wave heights occur after the barometer has bottomed out, and gale-force winds are reached only on the first uptick of the barometer. And in yet another case, the barometer falls quite rapidly, then levels out and climbs only gradually. Gale-force winds occur only on the dropping barometer, and have ended by the time the barometer bottoms out.

The wind shift proves critical to distinguish between the types of systems where the most dangerous period occurs in the first few hours of the rising barometer. We have learned to pay careful attention to the wind shifts around the time when the barometer levels out, and the buoy data confirms the importance of wind shifts in predicting the severity of the weather on the rising barometer. A sudden shift through 90 degrees or more around the point when the barometer reaches its nadir, almost always indicates a symmetrical rise with winds equal to or greater than those experienced on the fall. A more gradual set of wind shifts, suggest we will experience gale-force winds on the rise, though there may be a delay of as much as twelve hours before they arrive. Minimal changes in wind direction suggest a slowly rising barometer and a reasonable chance that gale-force winds have ended.

**As a forecasting tool, the barometer most closely resembles a depth sounder.** With respect to the weather, we always want to know what’s coming next. First and foremost, we want to know whether or not we will encounter gale- or storm-force winds in the next six to twelve hours. When we left I believed the barometer would tell us that in the temperate and high latitudes if not in the tropics. In fact, we have found the barometer in isolation to be extremely unreliable at forecasting gales. The standard rule of thumb – that a drop of three millibars in three hours precedes gale-force winds – proves the exception rather than the rule when examined in the context of the buoy data. In the real world, this rule regularly fails us in one of three ways.

First, the rule results in far too many “false positives” by predicting gales when none materialize. To start with, simply taking a single three-millibar drop over a three-hour period yields literally hundreds of examples in the buoy data where a gale does not follow. By requiring a succession of three hourly periods to show a drop of three millibars over the reading three hours

before, the number of “false positives” declines to 65. Many of these occur at high barometric pressures as a high pressure system weakens without a low approaching, and the barometer then levels out. Adding the stipulation that the barometer fall below 1005 millibars during the three-hour period reduces the number of false predictions to 23. This combined rule coincides with 18 out of 20 gales or storms, which means that a gale actually occurs less than one time in two.

In addition to predicting gales when none materialize, gales can occur with an almost stable barometer at high barometric pressures. One common such system is a “clear gale” or “crush zone”, which results when a low pushes into a strong, stationary high pressure system packing the isobars of the high together and increasing the wind without a corresponding drop in the barometer.

Finally, in many cases where the barometer does accurately predict a gale, the warning comes too late, after the wind has reached gale force. In general, the barometer tends to move in lock-step with the changes in wind speed, with the largest changes in pressure almost exactly mirroring the highest wind speeds as can be seen in

Expecting a barometer to forecast the next six hours of weather based on the current trend is a bit like expecting the depth sounder to forecast whether or not the boat will be aground in the next six hours. The depth sounder provides a trend line – the water is shoaling or it is getting deeper – but it can’t guarantee that trend will continue. On its own, the depth sounder does little more than offer a last minute warning just before the boat goes aground. But in conjunction with an accurate chart, the depth sounder becomes incredibly useful for predicting whether or not adequate water lies ahead. In exactly the same way, the barometer can be used to find a position along the isobars of a synoptic chart, and predictions of future weather can be made based on the boat’s current position on the chart. Changes in pressure can then be used to verify whether systems are moving as forecast, and to alter the prediction as appropriate if they are not. When sailors didn’t have synoptic charts, they would have been more than happy with a system that accurately predicted a gale half the time, but in this day and age, synoptic charts offer the opportunity of greatly refining the barometer’s predictions.

As I finish this article, I’m listening to a gale shaking the rigging. The barometer ticked upward after a three-hour lull just as I got out of bed a few hours ago. That was accompanied by a sudden wind shift from southeast to southwest. The wind speed climbed from 15 to 35 knots in

ten minutes, and now gusts and fuses at 30-plus knots, sending *Hawk* dancing around her anchor. The VHF just broadcast a gale warning for SE gales veering SW, but I know the center has already passed by our position. Despite the sun breaking through the clouds, the combination of the wind shift and the barometer changes convince me that we've more strong winds on the way, and we're unlikely to be leaving the boat this afternoon.

© 2006 Beth A. Leonard & Evans Starzinger