Tim's Tips #4 : What's the Storm Doing?

Why should I read this?

If you've been through a hurricane you'll already know that before it comes, you'll find yourself making a lot of decisions, taking a lot of actions, and giving advice to somebody else – and that sometimes during the event you might have to do all three at the same time!

Up-to-the-minute knowledge of the position and movement of the storm relative to your location can be vital information in decisions and actions you need to take, and advice you give, to protect life and property. At those crucial moments the four-hourly official position updates can be too far apart to give you what you need to know, right when you need to know it. In addition, the point for which relative position is given in those reports may be some miles from where you are – and a few miles can make a huge difference!

So … The more you know in advance what's going to happen, and the more you know during the storm about what's happening and what to expect next, the better equipped you will be to do what you will need to do and be helpful to those who may be depending on **you** doing or saying the right things.

The good news is that you don't have to have a doctorate in meteorology to keep yourself well informed in these circumstances, and there is an inexpensive set of simple but effective tools you can easily obtain in advance and keep with you during the storm so that you'll have them ready to use before and during a storm strike.

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For inquiries: timothy.p.adam@gmail.com ver.1.5 2010/09/16

What tools will I need?

The tools you'll need:

- A (portable) barometer (for this purpose I recommend the digital barometer type that is typically integrated in a small "desk"-type electronic weather station[1] but be sure the model you choose actually displays the barometric pressure reading!),
- a simple magnetic hand compass (just like a Boy Scout would use!)
- a pair of arms on the same body (yours, or someone else's if you've got a willing candidate!)

Here's how you use these tools, to make good judgements, take informed actions, and give knowledgeable advice. And all this is based on standard facts you already know.

Is the storm moving closer to me, or further away?

Fact: The center of the storm is generally the point of lowest barometric pressure. Here's how you will use the barometer:

Using the barometer

The barometer measures the atmospheric pressure in the space where it is located. While the storm is approaching and passing you, take a look at the barometer reading every half hour and **write it down, recording the time and the barometer reading**. **If the pressure is consistently falling (i.e. the barometer reading is reducing), the storm is still coming closer to where you are.** While the storm is at its closest, there may be some fluctuations in pressure up and down for a few minutes at a time; if the storm is moving slowly this can go up and down for many minutes, an hour or even more, and the closer the eye comes the greater these fluctuations can be. But **when the pressure is consistently rising, the storm is moving further away from you.**

A "caveat" in interpretation:

There are special circumstances in which you may observe barometric pressure falling even though the storm has passed its CPOA (Closest Point of Approach) to your location, or rising even though the storm hasn't yet passed its CPOA. That may occur for example if the storm is rapidly fluctuating in intensity i.e. weakening before reaching CPOA, or quickly strengthening after passing CPOA.

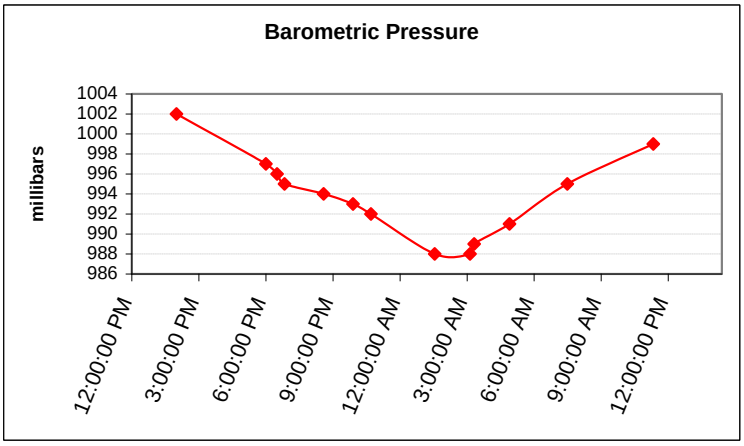
This phenomenon was observed in Grand Cayman during the passage of Hurricane Paloma in 2008: the storm was Cat. 2 at its CPOA to Grand Cayman and rapidly strengthened to Cat. 4 in the few hours before it reached Cayman Brac. At my location in Grand Cayman the barometric pressure had steadily risen after CPOA, then a few hours later it began a slight downward trend and kept falling for about four hours before resuming its upward trend around 3:00 AM. We now know during that period the storm rapidly intensified all the way from Cat.2 to Cat.4.

[1] For example, the "La Crosse Technology WS-8035U-IT-SAL Wireless Weather Station" [$74.99 at Amazon.com (7 Sep 2008) http://www.amazon.com/Crosse-Technology-WS-8035U-Wireless-Weather/dp/B0010OED12]

The chart below shows an example of how the barometric pressure changes as the storm moves closer, then past you, then further away from you.

Record of Barometric pressure during passage of Gustav 29 - 30 Aug 2008, measured at George Town, Grand Cayman

Time	Pressure
2:00:00 PM	1002
6:00:00 PM	997
6:30:00 PM	996
6:50:00 PM	995
8:35:00 PM	994
9:54:00 PM	993
10:42:00 PM	992
1:33:00 AM	988
3:08:00 AM	988
3:19:00 AM	989
4:54:00 AM	991
7:29:00 AM	995
11:20:00 AM	999
12:00:00 PM	



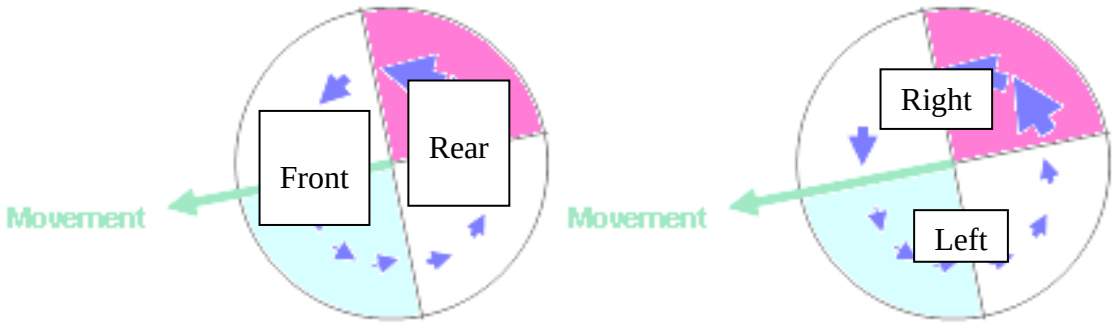
What are the (surface) winds going to do?

Fact: In the Northern Hemisphere, surface winds will tend to rotate counter-clockwise around the point of lowest barometric pressure. Simply put, this is a natural consequence of being located on the "northern half" of a spinning planet. (That's why water draining out of a tub will inevitably tend to rotate too.)

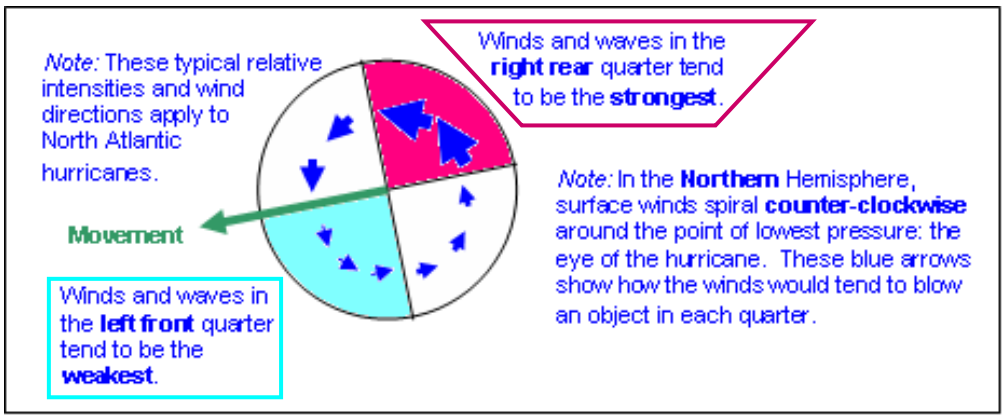
So … If you're smack dab in the centre of the storm, the surface winds will be circulating in a counter-clockwise direction around you. But of course even if the eye happens to pass directly over where you are, you're not going to remain right at the centre of the storm so the surface winds are going to be changing in direction. And given that the waves are driven by the surface winds, so too the waves will be changing direction.

Fact: In a tropical storm or hurricane, the storm is moving along, the winds are spiralling around the storm's centre, and all this is happening on the surface of a spinning planet! The net result of all those complex mechanics and dynamics is that the surface winds (and waves) are typically **not symmetrical** around the storm. For the purpose of this brief paper we don't need to get any deeper into physics as to why that is, but it boils down to some very helpful rules of thumb as to what *typically* happens in a hurricane, as shown in the sketches below.

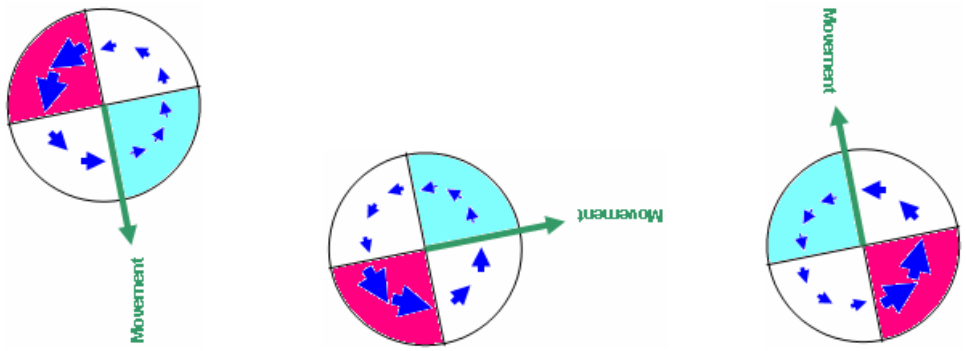
We will use the terms "front" and "rear" to describe the two main phases of the storm as it is passing you, "right" and "left" to indicate which side of the storm you will be on as it is passing you. Think of the storm as a car moving along: each of these terms "front," "rear," "right" and "left" are relative to the forward movement.



Combined, these terms define four "quarters", in which typically there are significant differences in winds and waves.



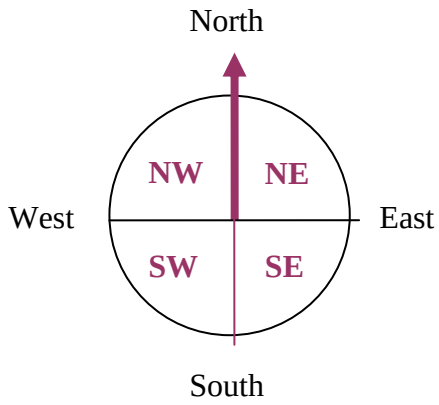
The blue arrowheads represent the surface winds, which blow in a spiral around the storm centre in a counter-clockwise direction. The waves would typically be moving in a similar direction to the winds. **If you point the green "Movement" arrow in the direction that the storm is moving, all the other quarters of the storm are re-oriented with it.** Here are some other examples.



Note: ***In all these diagrams and this narrative, the relative wind directions are approximate and illustrative only.*** *The wind direction relative to the storm centre is usually not a perfect circular pattern around the storm centre; for example* ***winds typically spiral slightly inward toward the centre of lowest pressure****, and the wind direction at your location can be influenced by the shape and positioning of buildings, other surface structures, cliffs, hills, mountains, or other topographical features in the vicinity. However the approximate directions are useful to estimate the relative location of the storm centre from your position while it is passing by your location, especially if you don't have access to an accurate source of up-to-the-minute data on the storm centre location.*

So … ***Just because the storm starts moving away from you, doesn't mean the winds or waves have become less of a threat!*** The difference in wind intensity in the different quarters often result in the **wind strength and wave damage** in the "**rear half**" of the storm being **greater than the front** (*but note: the* ***storm surge*** *risk might still be worse in the* ***front*** *of the storm, depending on the relative orientation of the affected coastline*). And, as the storm passes the wind **will shift to different directions**, depending on where you are and where the storm centre moves.

So … To get a good idea of the extent of asymmetry to expect in a particular storm, download the latest "Forecast/Advisory" for the storm[2]. This text will include forecast data for each of the four quadrants.



The **quadrants** of the data points **in the Forecast/Advisory** are defined by the cardinal points of the compass (relative to North).
The **quadrants** in the Forecast/Advisory therefore **do not directly correspond to** "left-front", "right-rear" etc. **quarters** of the storm **because the orientation of the quarters (relative to the compass points) depend upon the direction of the storm's movement.**

[2] The U.S. NOAA/NWS/NHC "Forecast/Advisory" is available from
http://www.nhc.noaa.gov/ - click link for "**Forecast/Advisory**" for the storm of interest
http://www.wunderground.com/tropical/ - click on the storm of interest, then click link for "**Marine Advisory**"

Here is a real-life example of a portion of a Forecast/Advisory:

```
HURRICANE CENTER LOCATED NEAR 22.4N  67.1W AT 06/0900Z
POSITION ACCURATE WITHIN  15 NM

PRESENT MOVEMENT TOWARD THE WEST-SOUTHWEST OR 255 DEGREES AT  14 KT

ESTIMATED MINIMUM CENTRAL PRESSURE  962 MB
EYE DIAMETER  25 NM
MAX SUSTAINED WINDS 100 KT WITH GUSTS TO 120 KT.
64 KT.......  40NE  35SE  30SW  35NW.
50 KT.......  60NE  50SE  45SW  50NW.
34 KT.......110NE  90SE  90SW 105NW.
12 FT SEAS..360NE 120SE  90SW 330NW.
WINDS AND SEAS VARY GREATLY IN EACH QUADRANT.  RADII IN NAUTICAL
MILES ARE THE LARGEST RADII EXPECTED ANYWHERE IN THAT QUADRANT.
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The **radius** of each level of wind speed in each quadrant means: in that quadrant, the [specified wind speed] can extend out a maximum of [radius in nautical miles] away from the centre of the storm.

Note: Realising that this example storm is presently moving roughly westward, the data are consistent with the "rules of thumb" stated above for the typical relative intensities in each quarter of the storm. In this example, at the time of the forecast it is estimated that hurricane force [64 knot] winds are extending out a maximum of 40 nautical miles somewhere in the north-east quadrant (which covers most of the "right-rear" quarter of this storm), whereas in the south-west quadrant (covering most of the "left-front" quarter) they extend out only 30 nautical miles. The Tropical Storm Force [34 knot] winds are also asymmetric. Notice too how asymmetric the rough sea wave intensity is: 12 ft seas forecast in the north-east quadrant (mostly "right-rear" quarter) up to 360 nautical miles away from the storm's centre, but only 90 nautical miles out in the south-west quadrant (mostly "left-front" quarter).

So … You can put all this together into what **you will be able to know**:

- You will know the **direction of the storm's movement** based on local official warnings, or forecast charts showing its expected direction of movement when it is passing your location. (*Note:* The "Forecast/Advisory" also gives a summary statement as to the storm's **present** movement – direction and speed - but that's not necessarily the movement it will have when it passes by your location.)
- From that: you will then know the **orientation of each of the four quarters** of the storm (at the time the storm will be passing you).
- Knowing your position relative to the storm's forecast track, you will then know **which side (right or left) of the "front" and "rear" phases you will be in when the storm passes you**.
- Knowing the **extent of asymmetry**, you will then know **what to expect as to the difference in intensity between the "front" phase and "rear" phase of the storm's passage.**
- Knowing which quarter you are going to be in during each phase, and knowing that the wind circulation is counter-clockwise around the storm centre, you will know **what direction to expect the wind to be blowing when the "front" phase approaches**, and you will know **how you expect the wind direction to shift as the**

storm passes through the "front" phase at your location then keeps on moving past you through the "rear" phase at your location.

Where is the storm right now, and what next?

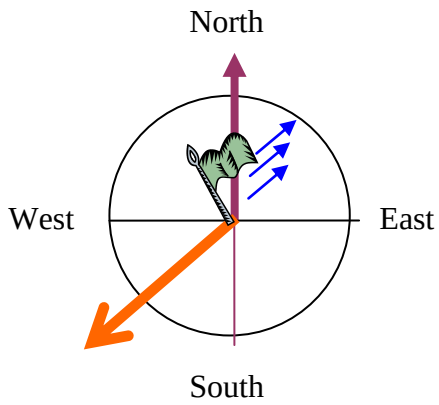
During the storm strike, to know which **quarter** of the storm you're in at the time, you need to know roughly where you are relative to the storm's centre (in addition to knowing what direction the storm is moving). But **first you figure out where the storm's centre is relative to where you are**, and **then you will know where you are relative to the storm's centre**. And **then you will know which quarter of the storm you're in at that time**.

Here is where we use the last two tools.

Using the hand compass

First of all, use the hand compass at your location to **get yourself oriented: find out where each of the cardinal directions are (North, South, East, West)**. Spot a "landmark" very close to your vantage point(s) for each direction from your location, so you won't have to keep checking the compass every time you need to check a direction. The "landmark" can be a nearby tree, wall, house, post, - anything that's close enough to remain visible in heavy rain – just something that will help keep you oriented as to which direction is which. And of course if you do forget you can just check your hand compass again!

Next, practice some method to **find out which direction the wind is blowing from**. A flag, fronds on a palm tree, leaves on some other tree, or observing the direction the rain is falling, are all simple but practical methods of figuring out where the wind is blowing **from**[3]. Nearby large buildings and other large structures can distort wind flow though, so bear that in mind when choosing your "wind direction gauge". In any case, it's important to **refer to wind by where it is blowing from**, because that is how it is referred to in official forecasts and just about everywhere else that it's mentioned. So if you are situated to the north-east (NE) of a flag and it is blowing straight toward you, the wind is coming **from** the south-west (SW). If you are **facing straight into** that wind, you would be facing south-west.



The **wind direction** indicated in forecasts, advisories, charts, maps, etc. is usually referring to the direction **from** which the wind is blowing. In this example of a flag being blown by the wind, this would be called **a south-west wind, or a wind from the south-west [SW]**. The flag is being blown toward the north-east. A weather vane is designed so that **the arrow points into the wind** i.e. the arrow on the weather vane points in the direction the wind is blowing from, like the orange arrow in the diagram. **The same is true of "wind barbs" or "wind feathers" on weather maps: they point to the direction the wind is coming from.**

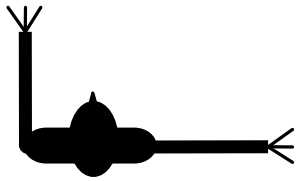
[3] If you have access to nearby local weather station data during the storm passage, of course that's a great source of information on wind direction. But don't rely solely on your link to that source, because the source or the link could be damaged and/or inoperable during the storm!

So … Knowing that the wind circulation is counter-clockwise around the storm centre, and knowing the wind direction (where it's blowing **from**) you can figure out roughly where the storm centre is relative to your location!

Using your arms and body

Here's how you will use your pair of arms on the same body (your body!):

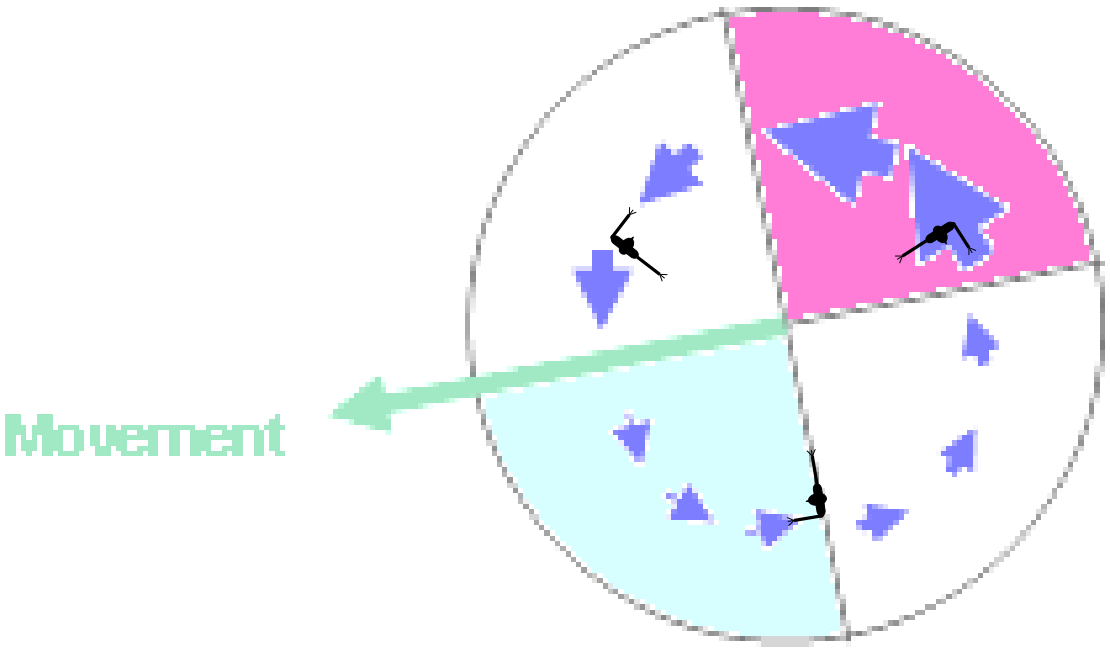
- Point your **left arm** straight out in front of you.
- Point your **right arm** straight out to the side.
- **Keep your arms in this same position – "lock them in place" - relative to your body while you do the rest of this exercise!**



- **Rotate your whole** body so that your **left arm** is pointing in the direction of the wind (i.e. where the wind is coming **from**).

> ***Note:*** ***I don't mean you have to go stand out in the storm to do this!*** Just stand in a safe place and line up the direction your left arm is pointing to be the direction where the wind is blowing from, i.e. **point your left arm straight into the wind**.

- And now your **right arm** will be pointing to where the centre of the storm is, relative to your location. As the diagram below demonstrates, this works when you are in any part of any quarter of the storm.



Which side of the storm am I on (left/right)? Which phase (front/rear)?

Of course as the storm moves along, its direction from your location is going to change, so the wind direction is going to change.

- By repeating this periodically you can get a good idea of the storm centre's movement as it passes you.
- ***Note:*** Given the different intensities in the different quarters of the storm, **if the storm ends up passing you on one side instead of the other it can make a huge difference in the wind and wave intensity and damage**. So if it's a close call, keep an eye on the rough direction of the storm from you as it passes by – it could be different than the forecast predicted! That way you will **always know which quarter of the storm you are in**.

So you will know how to use all your tools, you will have figured out what to expect, and you will be able to track what's going on and what's going to happen next with the winds (and waves) as the storm passes by. And by keeping yourself informed, you – and those who depend on you – will have a much better chance of preparing for the storm and faring much better through it.

Recommended Websites:

http://stormcarib.com/guide.htm :A Practical Guide to hurricane tracking and plotting
http://www.crownweather.com/tropical.html :"1-stop shop" for loads of storm info
http://www.stormpulse.com/ :Excellent graphics depicting forecast information
http://www.stormcarib.com/closest.htm :How close will forecast track come to you?
http://weather.msfc.nasa.gov/GOES/goeseasthurrir.html :Infrared satellite imagery

http://www.wunderground.com/tropical/ :Text and graphical forecasts of storms
http://www.nhc.noaa.gov/ :Click link for "Forecast/Advisory" for the storm of interest
http://www.nhc.noaa.gov/index.shtml?text :Text-based for slower internet links
http://www.nrlmry.navy.mil/tc_pages/tc_home.html :Good info but "techie" interface

Websites **accessible from your mobile phone browser** (or BlackBerry):

- http://m.wund.com/tropical/ :Weather Underground Tropical site for mobiles
- http://www.nhc.noaa.gov/index.wml :US NHC weather index for mobiles
- http://cell.weather.gov/ :US National Weather Service index for mobiles
- http://www.nhc.noaa.gov/gccalc.shtml?text :Calculate distance between two Latitude/Longitude points e.g. from your location to storm centre's present coordinates
- http://wwwghcc.msfc.nasa.gov/cgi-bin/get-goes?satellite=GOES-E%20HURRICANE&lat=19&lon=-81&palette=spect.pal&mapcolor=cyan&zoom=2 :Replace the "lat" [Latitude] and "lon" [Longitude] numbers above, with those for where you want the image to be centered, but **be sure to enter West Longitude numbers as negative** i.e. with the - prefix as shown above.

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Timothy.P.Adam@GMail.com

If you spot any errors or omissions in this, please tell me right away by sending me an email message at the address shown above.

Stay safe & dry!
Tim