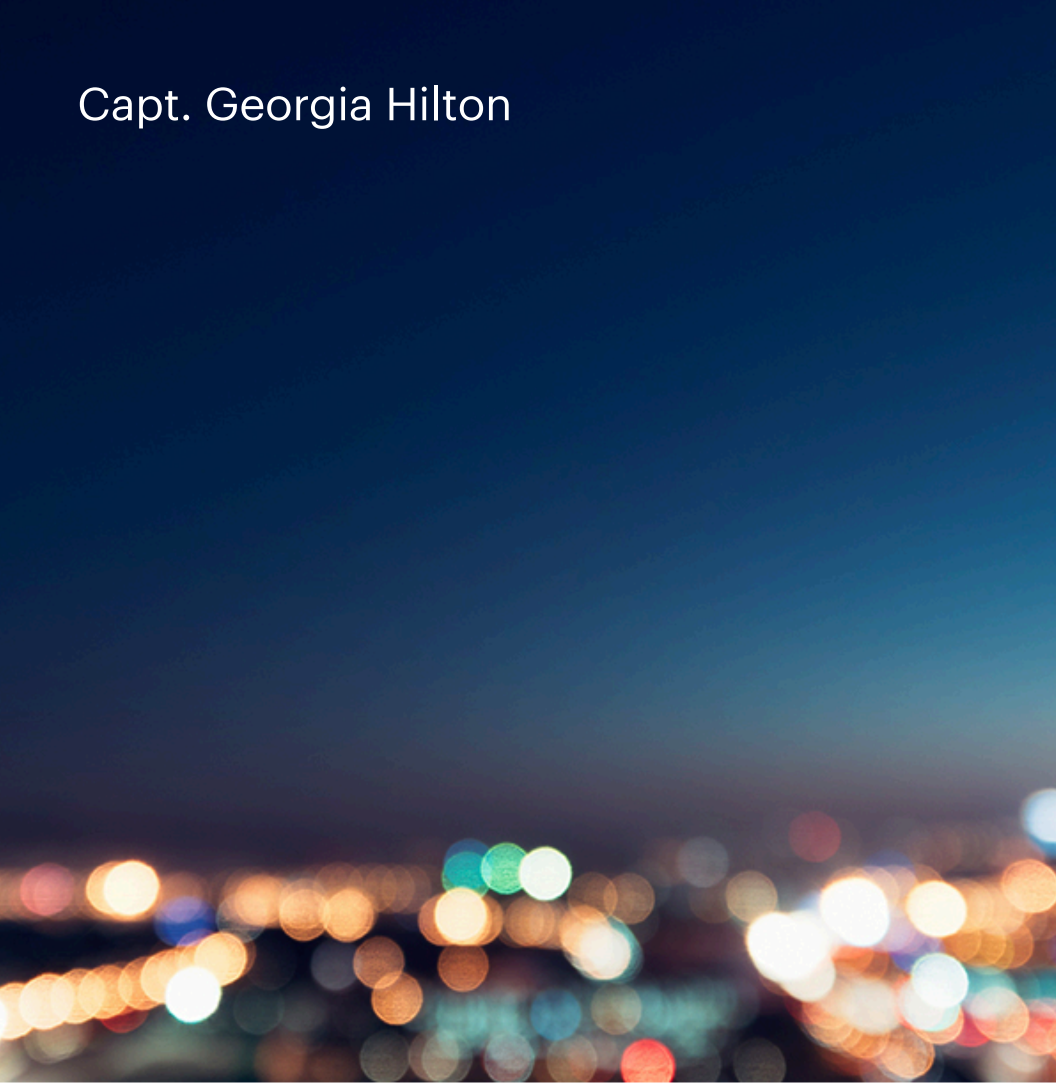
Capt. Georgia Hilton



WEATHER FOR THE MARINER

A PRIMER FOR WEATHER

This document is simply a brief primer on weather for the mariner. It’s designed to give you a brief overview of weather and things to help you understand the weather while underway.

INTRODUCTION

some basic questions

What is being weather wise. Can you answer these questions.

- **Tropical Cyclone. what do you do?**
- **Dangerous Thunder storm?**
- **What causes wind shifts?**
- **What is a sign from long large swells**

TROPICAL CYCLONE

All seafarers are well familiar with the term **'TRS' or Tropical Revolving Storm** – an intense rotating depression (a region of low pressure at the surface) which develops over the tropical oceans. It consists of a rotating mass of warm and humid air and creates thunderstorms with strong winds, flooding rain, high waves, damaging storm surge etc. Convectional forces are involved, normally stretching from the surface of such a depression up to the tropopause

They **form near the Inter Tropical Convergence Zone**, a zone of instability. They have **nearly circular isobars**. **No fronts occur** (a front is the boundary between two air masses, often distorted by warmer air bulging into the colder air). They result in a **very steep pressure gradient.** They have **great intensity.**

Monitor the barometer closely. If the corrected barometer reading falls below 3 mb or more for the mean reading for that time of the year (check the Sailing Directions for accurate information of pressure readings), you can expect a (Tropical Revolving Storm) TRS.

Note that the barometer used must be corrected for latitude, height, temperature etc. to achieve maximum possible accuracy and efficiency.

Understand and determine the following:

- The bearing of the eye (storm center)

- The path that the storm is following
- When an observer faces the wind, the eye will be 100° to 125° on his right hand side (in the Northern hemisphere) when the storm is about 200 miles away
- It is assumed generally that the storm is not moving towards the equator and if in a latitude lower than 20 deg. it is likely to have an Eastern constituent

- Avoid any wind field over 34 KT. Maintain a safe distance at least 50 NM. better more than 200 NM away from the center.

- In the **Northern Hemisphere: If the wind is veering**, you are in the **dangerous semicircle**. proceed at maximum safe speed keeping the wind at 10 to 45 degrees on the starboard bow. Turn to starboard as the wind veers.

- In the **Northern Hemisphere:** In case that the **wind direction is steady or backs**, such that the vessel is in the **navigable semicircle**, the wind must be brought well on the starboard quarter and vessel should proceed with maximum speed. Turn to port as the wind veers

- Watch the barometer. a swift fall in pressure indicates a brewing TRS. A vessel should continue on her course unless the barometer reading falls down by 5 mb or, by 3 mb in addition to high force wind. Avoid the center of the storm, make good speed.

- Follow a course away from the eye
- Steer for the area with shallowest waves and lowest winds
- Place the wind on the port bow and maintain speed

DANGEROUS THUNDERSTORM

Dark, threatening clouds are a sign of severe weather. The sharper, darker, and lower the front edge of the cloud, the more severe the storm.

A **steady increase in wind or seas**, or an **increase in wind opposite in direction to a strong current**. The wind may suddenly become stronger and gusty, often bringing heavy rain.

A **falling barometer indicates foul weather** is approaching. A rising barometer is a sign that good weather is coming.

The **ocean suddenly becomes increasingly choppy**, with waves moving in several directions at once.

If you can feel a **decided drop in the temperatur**e, it's likely a storm is coming.

- Head the bow into the waves at a 45-degree angle
- If the engine stops, drop a “sea anchor” on a line off the bow to keep the bow headed into the wind
- Point the ship into the wind or into the principle direction of the waves and swell
- maintain a slow safe speed to ride out the storm.

WIND SHIFTS

Storms / Fronts

Supercell formations, squall lines, and other large thunderstorms can cause significant wind shifts. Over the sea, waterspouts can form, which can cause a rapid increase in wind and change of direction.

The passage of a cold front can also cause a sudden change in wind direction. Before the front arrives, winds ahead of the front are typically out of the south-southwest. Once the front passes through, winds usually shift around to the west-northwest.

Sea breezes / Land Breeze

Each morning, air moves from the water to the land, forming a sea breeze. Later in the day, these pressure zones may equal out and the winds may diminish. However, as the sun sets, the scenario reverses and the pressures zones do a flip-flop. The wind direction changes from beach to ocean and a land breeze forms.

LONG LARGE SWELLS

Long, large swells at sea are caused by **wind transferring energy into the ocean. Distant storms.** The longer and stronger the wind blows, the larger the swell. This energy then spreads out into the ocean, similar to ripples in a pond.

waves no longer associated with local winds are swells.

Waves are created by **Duration** of wind, **strength** of wind and distance of **fetch**.

WEATHER BASICS

Weather Generation

Weather is created by heat. The earth heats differently around the globe. Additionally, the tilt of the earth causes seasons, which again cause heat differentials. The variation of heating, creates hot, cold and cold areas. these area differential in heat, causes air flow. Which causes wind. Which causes seas. And of course weather.

The rotation of the earth is close to 1000 mph. This moves air around the earth. Without gravity the air would simply spin off. At high altitudes around 18,000 ft the air flow has no friction and can move at speeds of close to 200 MPH or higher. This higher elevation winds flow around the earth creating the Jets Streams. Jet streams move heat and cause lower altitude masses to move creating our weather.

The angle of the round earth at various locations created a right hand curve to air flow in the Northern Hemisphere. Large air flow not only tends to travel from west to east (JET STREAMS drive these) but curves to the right. This curvature is created by the Coriolis Effect. Weakest at the Equator and strongest at the poles. This also affects weather.

The sun heats the earth differently on the ground and at sea. The water heats up through radiation down, close to 500 ft, but only heats the ground to a few inches. Therefore the larger the mass the longer the heat differential occurs. The ocean heats and cools much slower than the land. And, the ocean carries heat around the globe and dissipates that heat across larger areas, affecting weather.

SEASONS

The tilt of the earth is about 23.45 degrees. this angle varies throughout the year and is 0 degrees at the spring and fall equinox. the varying tilt is declination. (SEPT 23 and MARCH 21).

The earth rotates 306 degrees in 24 hours. The earth rotates around the sun in 365 days During this time the earth experiences the suns radiation in different amounts in different places. BTW the earth’s circumference is 24,860 miles   (21,639 NM)   1 NM = 1.15 statute miles. Every hour, the earth rotates 15 degrees.   360/24 = 15

All of these give us Spring, Summer, fall and winter and sets the basic weather. Additionally, the differential in heat across the globe creates air movement and thus wind. The uneven heating of the earth.

CORIOLIS EFFECT

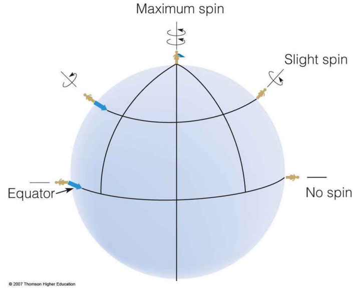
Wind is deflected to the RIGHT in the Northern Hemisphere due to the rotation of the earth. and to the LEFT in the Southern Hemisphere.

The Coriolis force is caused by the planet's rotation on its axis.

the Coriolis forces are stronger at the poles and weaker at the equator.
why? because at the equator there is no deflection

Because there is no turning of the surface of the Earth (sense of rotation) underneath a horizontally and freely moving object at the equator, the higher the latitude the more deflection from the coriolis force.

there is no curving of the object's path as measured relative to Earth's surface. The object's path is straight, that is, there is no Coriolis effect.
The Coriolis force is an imaginary force because objects affected by it are really following a straight path. It is an



apparent deflection we see from the vantage point (frame of reference) of the rotating Earth.

JET STREAM

Jet streams are strong winds that blow from west to east, around 5 to 7 miles above the Earth's surface.

The Sun doesn't heat the whole Earth evenly, so areas near the equator are hot and areas near the poles are cold due to less direct sunlight.

Jet streams are caused by these warm air masses and cold air masses in the atmosphere, interacting and moving heat.

Then on top of this the coriolis forces drive the wind to a west to east direction.

The centrifugal effects of the earth's rotation deflect the north-south transport of heat from the equator to the poles into the predominantly east-west motion of the jet stream.

Remember the earth rotates at about 1000 MPH at the equator and zero at the poles.

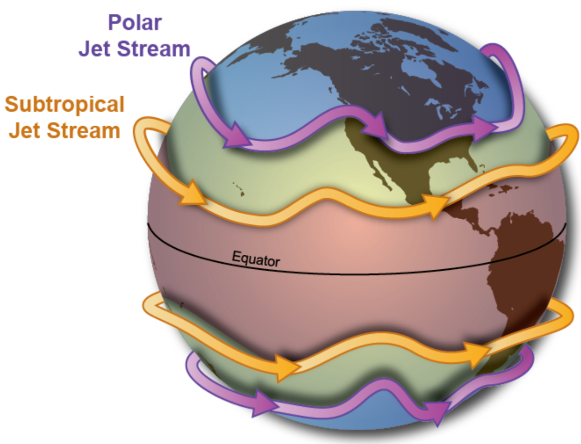
they can reach speeds of 200 MPH + due to air flow and earths rotational speed.

During the winter the jet streams are usually the strongest. These drive weather at lower altitudes.

POLAR
SUBTROPICAL

Jet streams are 3 dimensional.
the center of the jet stream can be up to 200 MPH while the outside edges are only 80 MPH.

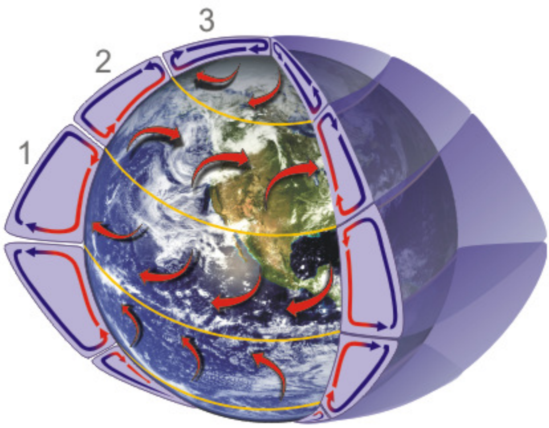
Jet streams follow the sun so they move up toward the poles in the summer



BOTH Hemispheres

Instead of one large circulation in each hemisphere, there are three circulations in each caused by these jet streams and Coriolis effects

1. Hadley cell – equator to low latitudes, air moves toward the equator, where it is heated and rises vertically. In the upper atmosphere, air moves poleward. This forms a convection cell that covers tropical and sub-tropical climates.
2. Ferrel cell – In this mid-latitude atmospheric circulation cell, air near the surface flows poleward and eastward, while air higher in the atmosphere moves equator-ward and westward. it was the first to account for westerly winds between 35° and 60° N/S, which are caused by friction, not heat differences at the equator and poles.
3. Polar cell – At higher latitudes, air rises and travels toward the poles. Once over the poles, the air sinks, forming areas of high atmospheric pressure called the polar highs. At the surface, air moves outward from the polar highs, creating east-blowing surface winds called polar easterlies. It is the smallest and weakest of the cells.



These cells move warm air up into the upper atmosphere (500 MB levels 18,000 FT) and cool air drops circulating air around the earth creating pressure variations. High Pressure and Low Pressure areas.

these high altitude pressure areas create the opposite low and highs at lower levels in the atmosphere (1000 MB levels , surface level, sea level About 300 FT)

Besides the later movement we've briefly hit on the vertical.   Gravity forces cold air down, allowing ti to displace the warm air that rises.   Warm air is less dense that cold air.

This is also why thunderstorms often form along weather fronts. A front represents the boundary where cooler, more dense air undercuts less dense, warmer air and forces it up into the atmosphere, forming the storms.

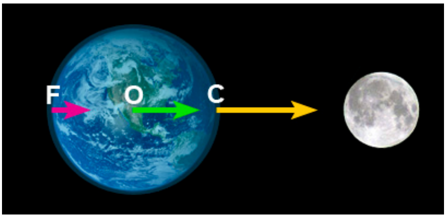
In meteorology, we often treat “pockets of air” in a similar way to ballooning. We call these pockets of air "parcels". A parcel is a bubble of air of no definite size that retains its shape and general characteristics as it rises or sinks in the atmosphere.

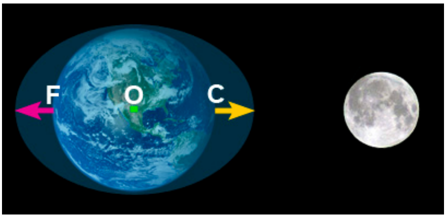
This creates the High and Low pressure areas that affect our weather.

TIDES

Vector math.

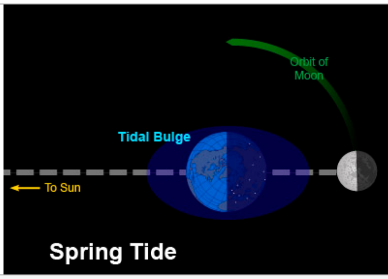
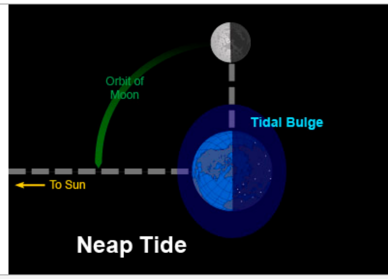
The pull from the moon’s gravity is more the closer to the moon.





moons gravity

additionally, rotational force causes water to build up thru inertia exceeding the gravitational pull of the moon.   water

	
10 to 30% higher (a foot or so here in Lauderdale	10 to 30% lower than normal
takes about 27 days for the moon to circle the earth	from new moon to new moon 29 days. this differential is due to the sun hitting the moon. so it appears this way on earth.

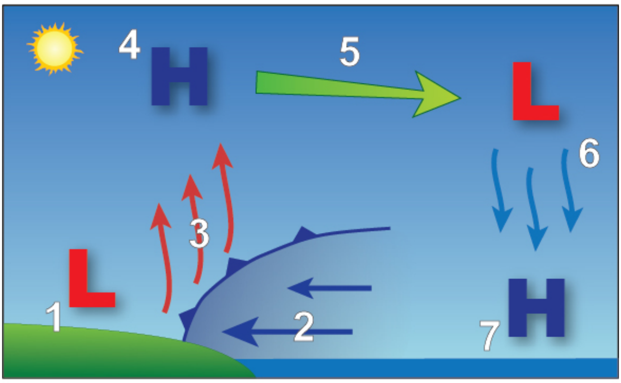
wants to keep going in a straight line.   if the moon didn't exist the gravitational force of the earth equals the rotationally generated inertia.

the water has to come from somewhere so the tides lowers elsewhere

transparency of water allows heat to be absorbed to down to approx 500 ft.

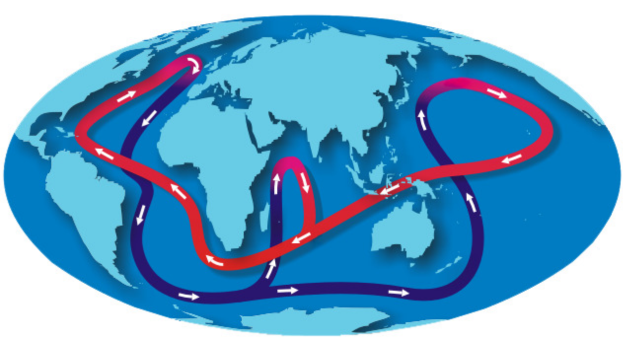
it takes a lot of energy to heat that much water. The top 200 ft are called the **epipelagic zone,** below that, **the**

thermocline... (down to 100 meters or 1600 Ft) also called **mesopelagic zone** below this the water is close to 4 c or about 39 F degrees.



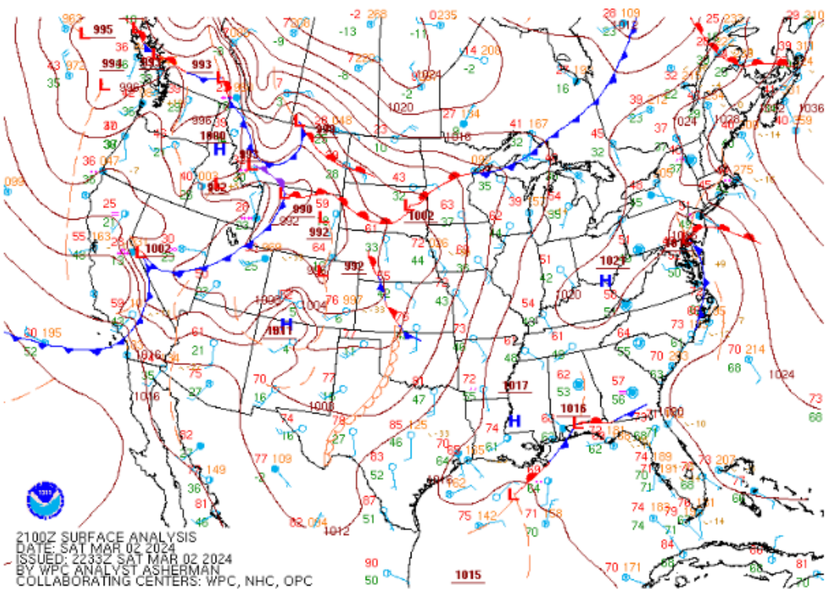
in contrast the heat of the sun's energy only penetrates a few inches. Therefore it heats and cools faster.   this differential creates sea breezes and land breezes.

the conveyer belt for heat in the ocean. up welling of cold water is wide spread but mostly in the pacific. and the warm water sinking is in the North Atlantic



COLD WATER is salter than warm water.   it takes about 1000 years for the high salt content water to rise to the upper levels again.

SYNOPTIC METEOROLOGY



SOME NOTES:

1 degree C = 1.8 degrees F
All clouds stop at around 20,000’ at the top of the Troposphere.

The reason is starting at the Tropopause air starts to warm again.

From the ground level to 40,000 ft air cools about 2 degrees F for every 100M (328 ft)   Adiabatic lapse rate.

Clouds form due to air cooling and no longer holding moisture.
low level: 0 - 2000M   6,500 ‘
mid level 2000m - 6000M   20,000’
high level 6000m and up… to 40,000’   Troposphere.

AIR MASSES

Continental Polar cP
Continental Tropical cT
Maritime Polar mP
Maritime Tropical mT

The Border between air masses are called FRONTS.

Cold Front - cold air mass heads toward a warm air mass
Warm Front - warm air mass heads toward a Cold air mass
Occluded Front - cold catches and fully overtakes warm front
Stationary Front - doesn’t move faster than 5 kts

Fronts always have a shallow slope angle.
1 degree for warm front
2 degrees for cold fronts

ever see contrails… they are an indiction of a warm front. they form due to warm damp air.

a DEPRESSION is just a area of low pressure.
they tend to flow from west to east.

they tend to bring high winds and rain for short durations due to the air rising inside them.

remember over a low the air is flowing in and up !

WARM FRONT APPROACH
if cirrus clouds are increasing its a good indication of a depression showing up in about 15 hours. as the warm front approaches the clouds lower and build.

WARM FRONT
NIMBOSTRATUS is the warm front rain cloud.
Once the rain starts the warm front is about 5 hours away.
As the front continues to approach rain increases (gets stronger) winds increase and cloud base continues to lower.

as the front approaches wind will begin to BACK (counter-clockwise)

WARM FRONT PASSES
As the front passes, we then move into the warm sector.
Once in the warm sector, temperatures rise and winds VEER (clockwise).

COLD FRONT APPROACH
Cold fronts have much more force than warm fronts.

Temperature will decrease
Winds can become strong, even gale force
Rainfall can become very heavy
Winds will VEER suddenly (clockwise shift)

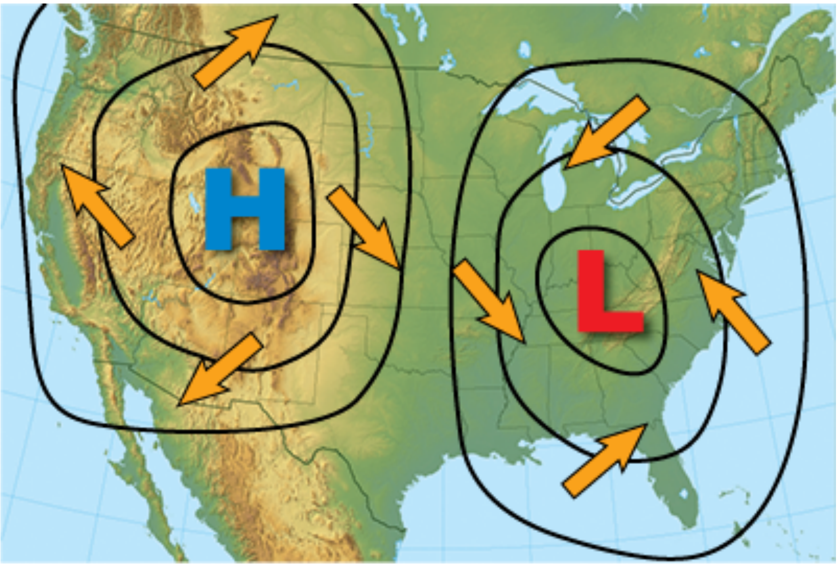
this stuff doesn’t last for long. They tend to be short and forceful.

there can be lingering light rain.

COLD FRONT
CUMULONIMBUS clouds are cold front storm clouds
convectional tall clouds. vertical development.

following the primary front passage you can get cumulus congestus tall cumulous then altocumulus

We use two basic type of weather maps: 1000 MB, surface weather and 500 MB approximately 18,000 ft for jet stream activity that drives the lower level weather.

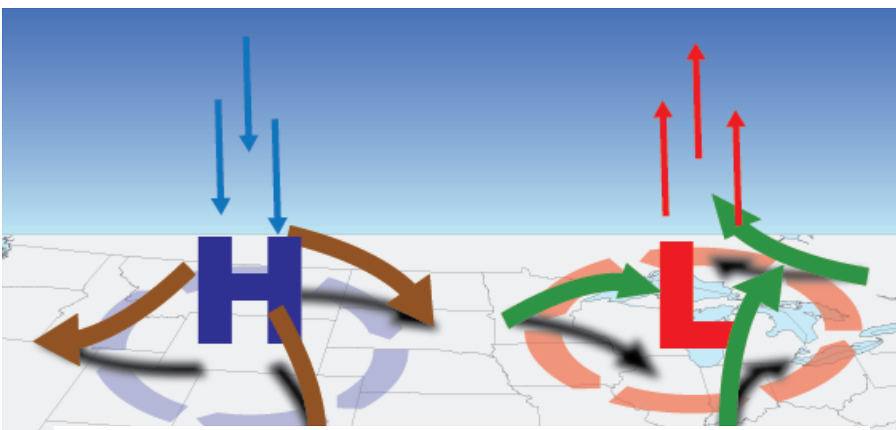


Air moves from High Pressure to Low

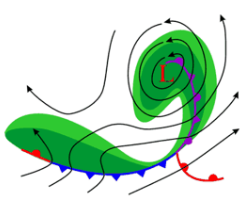
pressure.

These pressure gradients are measure with Air pressure using Milibars and depicted as ISOBARS on weather maps. Constant lines of pressure. 1013 MB is basic sea level. and every ISOBAR is a 4 MB differential up or down from the base of 1013 MB

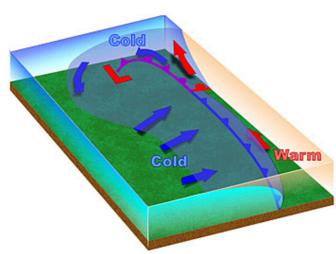
In the high pressure air moves down from the 500 MB region creating the high pressure and forcing the air out directly toward the low pressure. Except for eh coriolis effect. this bends the air flow (deflected) to the right. and down to the ground where its deflected to the right, lifted and into the low, lifting up towards the high in the 500 MB region.



As the cold front continues advancing on the warm front, the occlusion increases, progressively removing the warm moist air from the center of the low pressure system. Without the warm air mass to maintain it, the low-pressure system gradually dissipates.



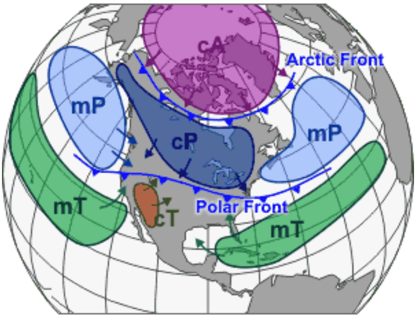
Dissipating stage of cyclone - overhead weather map view



Dissipating stage of cyclone - 3D view

What happens to the converging winds near a low? A property called mass continuity states that mass cannot be created or destroyed in a given area. So air cannot "pile up" at a given spot.

let’s go back to the air masses we spoke about earlier.
Continental Arctic air mass   CA
Continental Polar air mass   CP
Maritime polar   MP
Maritime Tropical MT



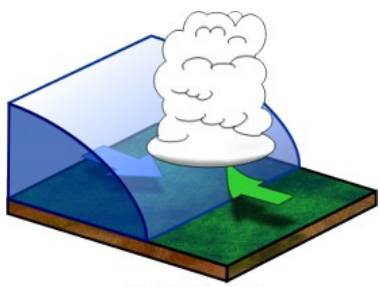
FRONTS

AIR MASSES meeting create fronts.
there are COLD air masses, WARM air masses and COOL Air masses that create fronts.

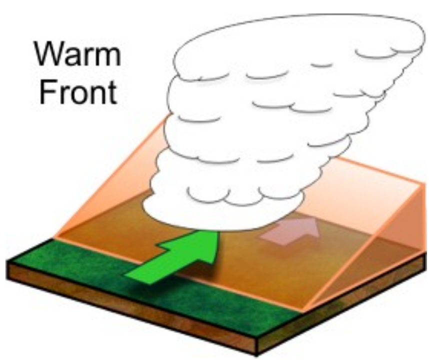
Fronts have both horizontal length (as seen on a weather map) but also Vertical size.

COLD FRONT a colder air mass is replacing a warmer air mass

WARM FRONT warm air replaces cold air.



Cold Front



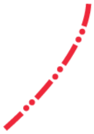
STATIONARY FRONT the boundary between two air masses does not move. Normally less than 5 kts in speed.

OCCLUDED FRONT COLD OCCLUSION: cold fronts, that move faster than warm catch up to the warm front and forces the warm front up from behind pushing the cool air mass out from under the warm air mass.

OCCLUDED FRONT WARM OCCLUSION: the cool air mass rises above the Cold air mass, both drive the warm air mass up over the cold air mass.

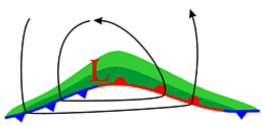
There are there sort of fronts out there. a DRY LINE marks the boundary of a very dry air mass and a moist air mass.

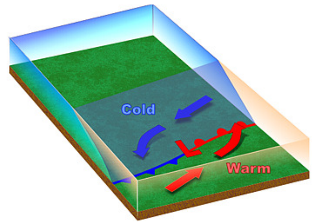
and a pre frontal trof. that normally tracks ahead of a cold front bringing more sever weather ahead of the front.

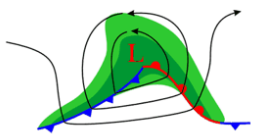


squall line - line of severe thunderstorms

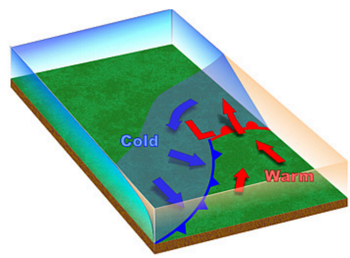
STAGES OF A STORM



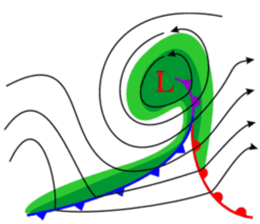




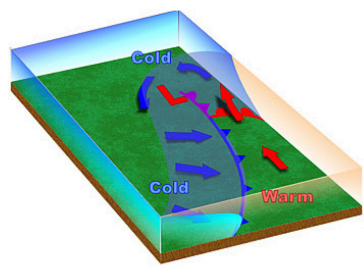
Wave intensifies - overhead weather map view



Wave intensifies - 3D view



A mature low-pressure system - overhead weather map view



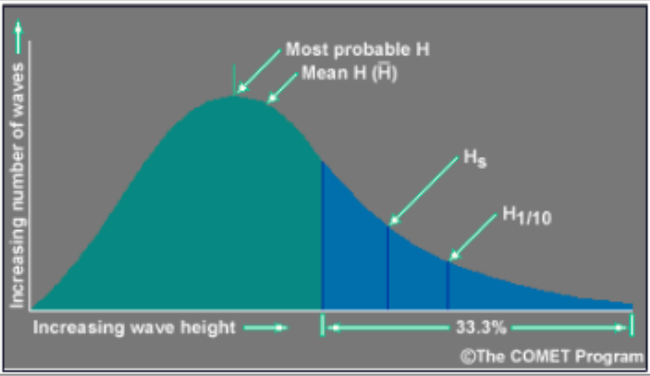
A mature low-pressure system - 3D view

WAVES

Waves are created utilizing Wind speed, Duration of blow and Fetch.

A steady 30 knot (33 mph/53 km/h) wind blew for 24 hours over a fetch of 340 miles.

Typical Distribution of Wave Heights



Explanation of the arrows being pointed to on the graph above:

- **H** is the most probable or the most frequent wave height, this is ***<u>not</u>*** displayed in the forecast. The most frequent wave height is approximately half the value of the significant wave height.

- **H (with the line above the H)** is the average weight height. This is ***<u>not</u>*** displayed in the forecast. The average wave height is estimated to be about 5/8 the value of the significant wave height

- **Hs** is the significant wave height. This is the average of the highest one third of waves. ***This is*** currently what is displayed in the forecast.

- **$H_{1/10}$** is the average of the highest 10% of waves observed. ***This is what is newly being displayed in our forecast. This is indicated by "Waves occasionally to xx feet".***

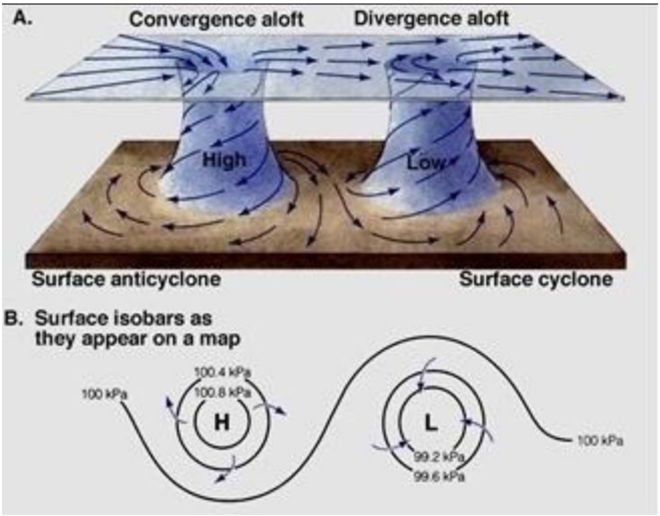
- 10% of all waves will be less than 3.6 ft. (1 m).
- The most frequent wave height will be 8½ ft. (2½ m).
- The average wave height will be 11 ft. (3 m).
- The significant wave height will be 17 ft. (5 m).

- 10% of all waves will be higher than 18 ft. (5 m).
- The average wave height of the highest 10% of all waves will be 22 ft. (7 m).
- A 5% chance of encountering a single wave higher than 35 ft. (11 m) among every 200 waves that pass in about 30 minutes.
- A 5% chance of encountering a single wave higher than 40 ft. (12 m) among every 2,600 waves that pass in about five hours.

CONVERGENCE / DIVERGENCE

High Pressure areas are areas where the atmospheric pressure increases. How does this happen?

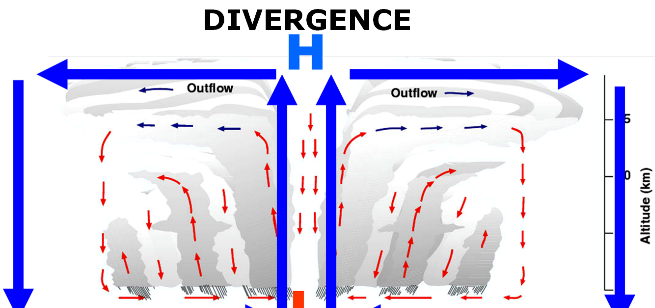
Warm moist air rises and diverges out in higher altitudes. the divergence is usually out of a high altitude High into the surrounding air from coriolis and upper air winds. As it does so the relative



humidity increases as the air cools and the air precipitates out the moisture.

The drier cooler air begins to descends down creating a large air mass converging and lowering all that air and descends as if standing on a scale creating a low in the upper atmosphere and s a High Pressure area in the lower atmosphere.

Wind



Pressure on a Vessel

WIND PRESSURE

PSF (LBS PER SQ INCH)

PSF = .00256 X (WIND SPEED SQUARED)

WIND LOADON A VESSEL

F (WIND LOAD FORCE in Short TONS)
A = SAIL AREA OF VESSEL
Cd= DRAG COEFICIENT

F = A X PSF X Cd

note: a modern ship assist tug can provide
around 60 tons of force at full operation

Example 1:
Let’s assume a 1000’ container ship fully loaded with a height from the water line of 75’ Let’s say the average area of the side of the ship = 800 x 75 or 60,000 square ft. of Sail Area.
let’s also assume a drag coefficient around .003 (in the average area for Cd of a large ship)
Beaufort Scale 4 11-16 Kts (let’s say 12 kts for the example)
PSF = 0.00256 x (12 X 12)
PSF = 0.00256 x 144
PSF = .368

F = A x PSF x Cd
F = 60,000 x .368 x .003
F = 66.24 Tons or **128,480 lbs of force on the side of the ship**
or the equivalent of one modern large tugs used in Ship assist pushing the side of the vessel a full capability.

Example 2:
Same vessel, but the wind is **Beaufort scale 6**, around 25 kts.
PSF = 0.00256 x (25 X 25)
PSF = 0.00256 x 625
PSF = 1.6

F = A x PSF x Cd
F = 60,000 x 1.6 x .003
F = 288 Tons or **576,000 lbs of force on the side of the ship.**
or the equivalent of almost three modern large tugs used in Ship assist pushing the side of the vessel a full capability.

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-19 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

WIN

To a … crossing a
cert… the surface
winc…

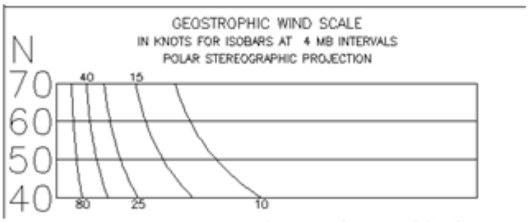
you can utilize 70% to 80% for realistic wind on surface level table 2.4-1

utilize a 1000 MB (Surface level chart)

1. measure the distance between isobars at the worst case in your area.

2. find your latitude.

go to geotropic wind speed and determine the geotropic speed.



Geostrophic Wind Scale

mark the distance from the left at the correct latitude.
this is geotropic wind at 600 M
wind speed at sea level = 70% of geotropic 600m wind speed.

50 kts at 600m 35 kts at sea level. potentially gusting to 50 kt

	Isobar Spacing - Degrees of Latitude																
Latitude	0.4	0.6	0.8	1	1.5	2	2.5	3	3.5	4	4.5	5	6	7	8	9	10
15	309	206	155	124	82	62	49	41	35	31	27	25	21	18	15	14	12
20	234	156	117	94	62	47	37	31	27	23	21	19	16	13	12	10	9
25	189	126	95	76	50	38	30	25	22	19	17	15	13	11	9	8	8
30	160	107	80	64	43	32	26	21	18	16	14	13	11	9	8	7	6
35	139	93	70	56	37	28	22	19	16	14	12	11	9	8	7	6	6
40	124	83	62	50	33	25	20	17	14	12	11	10	8	7	6	6	5
45	113	75	57	45	30	23	18	15	13	11	10	9	8	6	6	5	5
50	104	70	52	42	28	21	17	14	12	10	9	8	7	6	5	5	4
55	98	65	49	39	26	20	16	13	11	10	9	8	7	6	5	4	4
60	92	62	46	37	25	18	15	12	11	9	8	7	6	5	5	4	4
65	88	59	44	35	24	18	14	12	10	9	8	7	6	5	4	4	4
70	85	57	43	34	23	17	14	11	10	9	8	7	6	5	4	4	3

Passage or Voyage planning,

is the procedure a crew must comply with before relocating a ship from one mooring to another.

It comprises a theoretical planning stage before the departure as well as a practical implementation stage during navigation.

The need for passage planning applies to all vessels in any type of voyage, including those under pilotage. Implementing a passage plan requires a thorough understanding of the underlying principles of the process.

You can find these principles from two key resources,
SOLAS Convention

IMO Resolution A.893-21.

Voyage planning is a complex process that involves many factors, including:

Appraisal

Gathering information about the passage, such as:

The captain's instructions
Company guidelines
Marine environment
Local regulations and warnings
Weather forecasts

Planning
Planning the details of the voyage, such as:

Safe speed
Necessary speed alterations en-route
Minimum under keel clearance

Accounting for factors
Considering factors such as:

Shipping deadlines
Cargo and crew safety
Fuel costs
Route optimization

WEATHER ROUTING

Weather routing is a process that considers many factors when calculating a route for a ship. These factors include:

Air temperature, Winds, Tides, Currents, Waves, Atmospheric pressure, Vessel resources, Safety, Comfort.

The results of weather routing are sent to the ship's navigational system, which then uses them to plot the best course.

Some things to consider when planning for weather routing include:

How the vessel model responds to the environment

The angle of the impact versus vessel heading

Climatic conditions

Vessel performance

Avoiding hazards

Maximizing boat speed

Initial route recommendations are a combination of:

Experience

Climatology

Weather and sea state forecasts

Operational concerns

The ship's seagoing characteristics

Weather forecasting services, such as the National Weather Service, provide detailed 10-day forecasts for wind direction and velocity. Some apps, such as Windy, also provide detailed forecasts for wind direction and velocity up to 15 days in advance.

Weather routing

First, let’s consider the question, what is weather routing?

Weather routing involves setting the route between 2 points.

Normal weather routing would typically involve deciding on the shortest possible distance between the point of departure and the destination.

For that route to be the optimum or most efficient route, however, you also need to consider many data points, including environmental factors such as wind speed, currents, and wave height.

You can effectively reach the combined goals of safety and reduced voyage costs by using the right marine weather routing software.

The right weather routing system will examine the current weather and the forecasted weather along the ship’s ideal passage.

The proposed route can then be modified according to climatic conditions and other factors, including vessel performance, and the user advised correspondingly.

Although the optimum route can be planned, things can change rapidly after a vessel leaves port. For this reason, your onshore teams need to receive detailed and up-to-the-minute weather information. This real-time information means that routes can be continually adjusted as required.

The aim of optimized weather routing is not simply to avoid all adverse weather completely. The fundamental idea is to find the most efficient route.

Routes that minimize fuel consumption without compromising the safety of all involved in the operation.

Once various data has been analyzed the optimum route will then be conveyed to the ship's captain via weather routing software.

During the voyage, all the required navigation information will be continuously supplied to the captain and the helmsman by the routing software. Using an expert marine route guidance system removes some of the navigation challenges.

Note that the optimum route is calculated not only according to environmental aspects such as weather forecasts and ocean currents.

The ship's unique characteristics and specifications and the type of cargo the vessel is carrying are also factored into the equation.

Weather optimized routing is a safe, point-to-point route planning that considers speed and heading recommendations.

It also takes into account impacts from environmental forces on a vessel's performance. The aim of optimized weather routing is to find the most efficient route.

Routes that minimize fuel consumption without compromising the safety of all involved in the operation.

The aim of weather routing is to achieve optimum speed in order to perform the voyage as energy efficient as possible. This reduces bunker consumption while providing the safety of ship, crew and cargo.

Weather Data - The higher the resolution the better and the timelier the better.

Vessel profile - capability, design, propulsion, hull etc.

There are several routing types available:

- **Fixed Speed:** Set single speed, as designated in charter party
- **Flexible (Variable) Speed:** A speed range used in the routing calculation
- **Fixed ETA**: Speed range allowing variable speed to avoid weather, while still getting to the destination at a set time.

Who is in Charge of Passage Planning

The legal responsibility for the passage planning process lies on the vessel's captain.

In practice, the captain often delegates such duty to a Navigational Officer, or Officer On Watch (OOW). Navigational Officers (i.e. Captain, Chief Officer, Second Officer, or Third Officer) are essential players for successful onboard management.

They exercise responsibility for the people, cargo and the vessel itself from port to port. These officers make important decisions on navigation, communication, general maintenance, day-to-day dock operations and overall ship operation.

The important role of ECDIS in Passage Planning is another reason that captains entrust Navigational Officers with this task. Generally, only they possess the necessary experience operating the ECDIS.

The four stages of voyage planning are:

4. Appraising all relevant information
5. Planning the intended voyage
6. Executing the plan taking account of prevailing conditions
7. Monitoring the vessel's progress against the plan continuously

Here are some other tips for planning a voyage:

- Select the right season and window within that season
- Shape your route along the path of least resistance
- Match the vessel and crew to the anticipated conditions
- Ensure that all crew members are trained and familiar with the emergency response plan

- Know their roles and responsibilities in an emergency situation
- Monitor weather and sea conditions during your voyage
- Adjust your route or speed as necessary to avoid hazardous condition

1. Appraisal

The ship's master will discuss with the second mate (the officer in charge of navigational matters) on the voyage order received, destination port and how he intends to sail there. Based on the master's advice the officer will gather all information relevant to the proposed passage, including ascertaining the risks and assessing its critical areas.
The following are, but not limited to, publications or e-publications, charts or e-charts and information used in passage planning:

Chart catalogue	Type of cargo in carriage
Charts/Notices to Mariners	Guide to Port Entry

Routing Charts/Load Line chart	Port Distance calculating software/table
Ocean Passages of the World	Ship Routing system
Mariner's Handbook	Navigational and Weather warnings
Admiralty Sailing Directions	Drafts, UKC and stability data
Admiralty List of Radio Signals	Past experiences of officers for the voyage
Admiralty List of Lights and Fog Signals	Company's standing instructions
Admiralty List of Radio Signals	Master's standing instructions
Tide Tables and Tidal stream	Charterer's instructions

2. Planning

Once an appraisal is made using the publications and information in hand, the officer will prepare a plan which is detailed and simple to understand.

The plan is first laid out on a small-scale chart, which is then transferred to charts of suitable scales, and then tweaked and modified as and when deemed necessary.

It is a good standard practice to lay out the plan from berth to berth and to mark dangerous areas such as:
wrecks, shallow areas, hazardous coastal areas, fish farms or fishing zones, reefs, small islets, anchorages, heavy shipping, density areas,

also, Traffic Separation Scheme precautionary areas and any other relevant information that will assist with safe navigation.

The voyage may not go as planned and emergency action may be required when the voyage has to be deviated or aborted.

Contingency plans account for such situations, so that the Officer on Watch (OOW) can take immediate action. Contingency planning will include alternative routes, safe anchorages, port of shelter, waiting areas and emergency berths.

The master should thoroughly review the passage plan and provide corrective instructions where necessary.

If it is stated in the company SMS (Safety Management System) that shore management should also review the passage plan this is to be effected only with the intention of having one extra barrier in place in order to ensure the highest quality and reduced risk.

A detailed risk assessment and briefing by the master prior to departure should be performed with the members of the bridge and engine teams.

3. Execution

Once the passage plan is reviewed and approved by the master, the bridge team will execute the plan.

During the passage the speed is adjusted by the master based on the ETA, traffic density and the sea and weather conditions.

The onboard quantity of fuel, water and food ration should also be taken into consideration to prevent shortages.

4. Monitoring

This phase is where the bridge team use their experience, personal judgement, and good seamanship to monitor the safe passage.

Monitoring is checking the position of the vessel by all available means, to ensure it remains within safe distance from any hazardous areas. Plotting the ship's position using more than one method is a good practice and those include e.g. GPS, visual bearings, radar range/bearings and astro-navigation.

At the end of a voyage, a de-briefing meeting is to be held to share experience and lessons learned from the conducted voyage. This information can be used in future passage planning.

MAYFOR CODING

https://vos.noaa.gov/

World Meteorological Organization (WMO)

The Voluntary Observing Ship (VOS) program is organized for the purpose of obtaining weather and oceanographic observations from moving ships.
An international program under World Meteorological Organization (WMO) auspices, the VOS has over **5000 vessels** participating from **23 nations**.
It is part of the WMO Global Observing System of the World Weather Watch.

The worldwide weather reporting schedule for Voluntary Observing Ships is 4 times daily
at 0000, 0600, 1200, and 1800 UTC

Vessels operating on the Great Lakes, and within 200 miles of the U.S. or Canadian coastlines (including the coasts of Alaska, Hawaii, and Gulf coast states), are asked to transmit their observations once every three hours — at 0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 UTC

MArine **FOR**ecast

A MAFOR code begins with a date and time group, followed by the name of the area to which the forecast applies, followed by one or more groups of five figures, which may be followed by another optional group.

National Weather Service Observing Handbook Number 1.
https://vos.noaa.gov/ObsHB-508/ObservingHandbook1_2010_508_compliant.pdf

Sea State

Beaufort	Knots	wave	Seas
0	0	0	glass
1	1-3	3-6”	ripples
2	4-6	6”-1’	wavelets (small)
3	7-10	2’-3’	wavelets (large) small white caps
4	11-16	3’-4’	small waves occasional breaking
5	17-21	6’-8’	Moderate waves
6	22-27	9’-13’	Large waves. foam crests, spray
7	29-33	13’-18’	piling up, large seas, breaking waves
8	24-40	18’-25’	High seas of greater length
9	41-47	23’-32’	High waves, foam, breaking and waves
10	48-55	29’-41’	Very high waves. sea appears white breaking seas
11	56-63	37’-52’	Extremely high waves
12	64 +	52+	Air filled with foam spray, massive seas.

WIND force

Force per square foot experienced when wind is blowing perpendicular to a surface is calculated using this formula: F = 0.004V(squared) F = wind force measured in pounds per square inch V = wind velocity in knots

Wind Speed	Force (lbs./square foot)
10	0.4
15	0.9
20	1.6
25	2.5
30	3.6
34	4.6

approx 20,000 square ft of windage on a 500 ft long by 40 ft high ship side.

at 10 Kts   20,000 x 0.4 =   8,000 lbs of force.
at 20 kts   20,000 x 1.6 = 32,000 lbs of force.

EXAMPLE	MAFOR for DRY TEMP	1ttt	
Dry temp 30 F			
Convert to C	-1.1		
First position is fixed	1	1 x xxx	
Second position is sign	Neg = 1	11 xxx	
last 3 are temp	11	11011	

EXAMPLE	MAFOR for DEW POINT	2ttt	
Dry temp 30 F	Wet Bulb 28 F		
Convert to C	-1.1 C -2 C		
Find DEW point differential	1 C = - 4 C on chart		
First position fixed	2	2 x xx	
Second position is sign	Neg = 1	21 xx	
last 3 are temp	-04	2104	

EXAMPLE	MAFOR for CLOUD COVER includes wind True direction and speed	Nddff	
Cloud cover	50% = 4/8 = 4 on chart	4 xx xx	
Wind direction convert to True	340 relative = 20 off port bow	=220 T @ 5 kts	course 307 T @ 12.6 kts wind 340 R @ 14kts
encode wind T direction	220 T = 22 on chart	4 22 xx	p 2-20
encode wind T speed	5 kts = 05 kts	4 22 05	

		42205	

EXAMPLE	hove to in Hurricane 242 T	Nddff	wind is 260 R @112kts
Cloud cover	50% = 8/8 = 8 on chart	8 xx xx	
Wind direction convert to True	242 T + 260 R = 502 -360 = 142 T		
encode wind T direction	= 142 T = 14	8 14 xx	p 2-20
encode wind T speed	over 99 kts = 99 (max)	814 99	
		81419	

EXAMPLE	Encode position	99LLL QLLLL	
Position	10 38 S LAT 00 14 E LON		
LAT Encode	10 = 10 38 min = .6 = 6	99 10 6	p 2- 8
encode quadrant	S and E = 3	99106 3 LLLL	p 2-9
LONG encode	00 = 000 14 = .2 = 2	814 99 30002	

		81419 30002