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How to analyze synoptic-scale weather patterns

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Before You Begin

Start the synoptic scale analysis at least 8 – 10 days out to establish trends prior to a long passage. This is usually long enough to get a sense of what is happening prior to your departure in order to get the best sense of what you might expect after your departure.

For purposes of our analysis, we will be referring primarily to the following U.S. charts. However, nearly any government weather service chart can be used.

NOAA's Ocean Prediction Center (OPC) produces the following **surface pressure maps** among others:

a. **Surface Analysis Map** (actual conditions; produced every 6 hours; 0000, 0600, 1200, 1800 GMT)
b. **24-hr Surface Chart** (24-hr forecast; produced every 12 hours; 0000, 1200, GMT)
c. **48-hr Surface Chart** (48-hr forecast; produced every 12 hours; 0000 and 1200 GMT)
d. **96-hr Surface Chart** (96-hr forecast; produced every 24 hours; 1200 GMT)

The OPC also produces the following **upper atmosphere maps**:

a. **500 MB Analysis**
b. **24-Hr 500-mb Forecasts**
c. **36-Hr 500-mb Forecasts**
d. **48-Hr 500-mb Forecasts**
e. **96-Hr 500-mb Forecasts**

For information on how to obtain U.S. charts automatically, refer to the **Automatic Document Retrieval** tool.

The charts and schedules are subject to change, so check before each analysis.

For a listing and explanation of weather map symbols, click here.

Use the **Synoptic Scale Daily Weather Log** form to record your daily findings.

The process:

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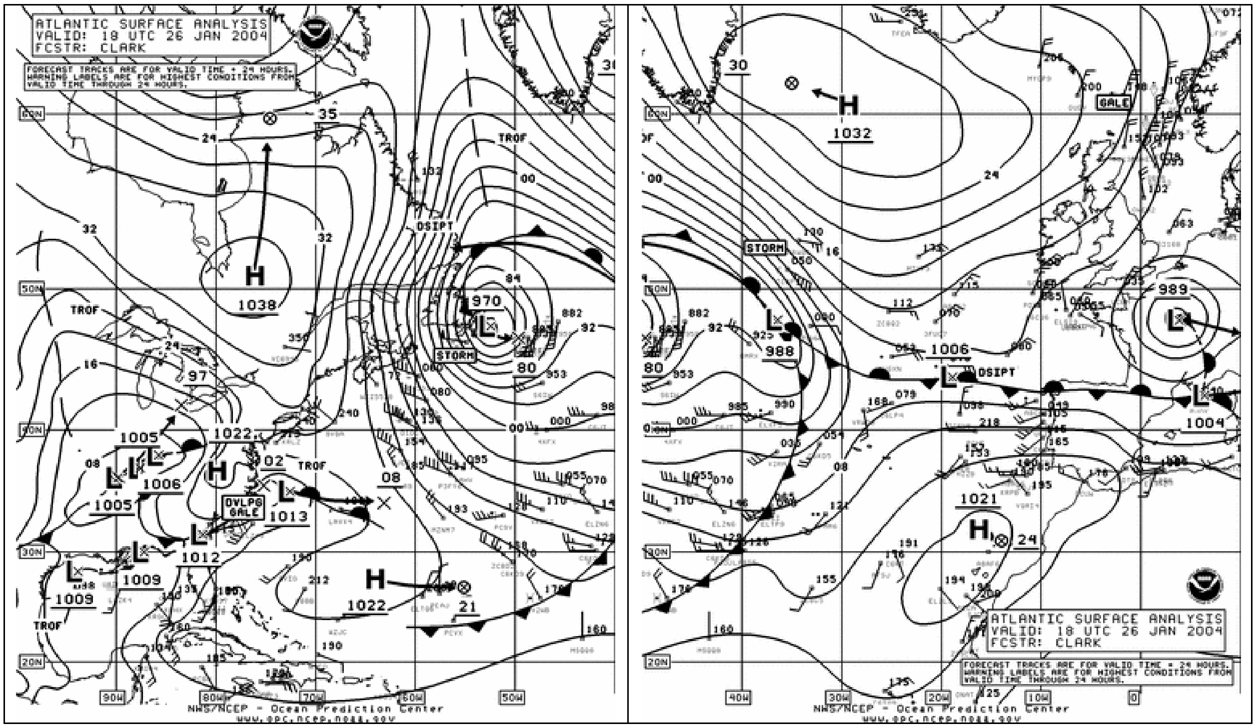
1. Identify H and L pressure systems

Introduction:

Locating H and L pressure system, including fronts associated with L pressure systems, is critical to forecasting synoptic scale weather patterns. The greatest challenge is to determine timing correctly. Anticipating that a large L pressure system is moving into your area, but misjudging its arrival by 12 hours, can be devastating to your race strategy or the comfort level of your cruise.



Examples of Surface Analysis Charts for Atlantic Region (Eastern Atlantic – Part 1 and Western Atlantic – Part 2).

Procedure:

STEP	ACTION	ANALYSIS QUESTIONS
1.1	Using Surface maps, identify any H or L pressure system moving towards your position. **Plot the movement of the center** of the system at least once per day, at the same time of day. Select a time of day when it will be convenient for you to save and store forecasts over a series of days (e.g., 1200 GMT is 8 am EST).	Answer the Analysis Questions for each pressure system you are tracking: 1. In what direction is the pressure system moving? 2. Is that direction a straight line, or is it curving? 3. What is the speed of movement? 4. Is the speed accelerating or declining? 5. Based on the observed movement (direction and speed), estimate the predicted position of the system 24 hours in the future. Movement of Lows – average summertime speed is 430 nm per day (18 knots) Movement of Highs – average summertime speed is 390 nm per day (16 knots) These averages vary greatly, and both Lows and Highs can stall for days.

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STEP	ACTION	ANALYSIS QUESTIONS
1.2	Animate movement of weather features (optional step).	See Analysis Questions above. ➢ To get a 'visual' sense of the movement of weather patterns, you can "animate" a series of surface analysis maps by printing out maps for the same geographic area and time interval and "fanning" or "flipping" them like a child's flip book. ➢ You can also have the computer 'animate' a sequence of static graphics in a "slideshow." For an example, refer to the **Animating Synoptic Weather Charts** tip. ➢ To increase the visual information, you can also color the Lows, Highs and Fronts the same color each day so that the movement of particular features becomes more easily apparent.
1.3	Note the **barometric pressure** of the H or L system. The pressure is a 2 or 4-digit underlined number indicating the pressure in millibars (mb): for example, 1024 or 99 could be represented as 24 or 999. The "10" and "9" (respectively) are assumed.	Is the pressure in the center of the system increasing or decreasing? Remember: ➢ Lows weaken with rising pressure and get stronger with lowering pressure. ➢ Highs weaken with lowering pressure and get stronger with rising pressure.
1.4	Compare your own predictions of the movement of the H and L pressure systems with the Forecast charts for the same Valid Time. This will validate your ability to interpret H and L pressure systems on weather charts.	Do your answers agree with the 24-hr Surface Forecast Chart? Remember: ➢ On Surface charts, the centers of Highs are indicated by a **circled "⊗."** ➢ The centers of Lows are indicated by an **"X" with no circle**. ➢ **Bold arrows pointing toward** the High or Low indicate where it was 24 hours PRIOR TO the valid time in the box. ➢ **Bold arrows pointed away** from the High or Low indicate where it will be 24 hours AFTER the valid time in the box. For a more detailed description, refer to Weather Map Symbols.

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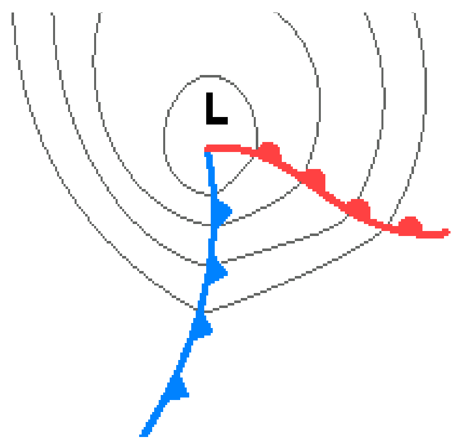
2. Locate fronts and determine frontal activity

Introduction:

Fronts are associated with sub-tropical L pressure systems – almost never with H pressure systems, nor with tropical depressions. Fronts are the boundary between different cold and warm air masses. Fronts are important to sailors because they indicate a change in weather, including rain and possibly increased wind.

Procedure:

STEP	ACTION	EXPLANATION
2.1	Locate all fronts on the weather map. ♦ Cold ♦ Warm ♦ Occluded ♦ Stationary	For an explanation of weather map symbols, click here. ➢ If the chart does not identify the fronts, you can use isobars to locate fronts. ➢ Troughs, or elongations in the isobars extending from the center of a Low, indicate a drop and subsequent rise in pressure as you move across the chart. These troughs often indicate the presence of a front (boundary between cold and warm air masses).  Troughs may be U-shaped or V-shaped. A front can bisect the trough (located directly in the middle of the U or V), or can be located behind or ahead of the trough. If the weather map does not show where the font is located, you won't know by looking at the trough. However, you could compare the weather map with a satellite image showing frontal cloud formations. ➢ A ridge is an elongation of isobars pressure extending from the center of a High pressure area.

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STEP	ACTION	EXPLANATION
2.2	Confirm frontal or pre-frontal activity by infrared (IR) satellite images.	➢ The IR image will usually show a band of clouds indicating a front or squall line preceding the front. Locate the cloud line with the highest, coldest clouds (generally, the higher the cloud, the colder it is). ➢ Cold fronts will have tall, cold, towering cumulus clouds often associated with squall lines either along or preceding the front. ➢ Following a cold front, there is often general clearing (as the air turns cool and dry). ➢ The air preceding a warm front will be cloudy and rainy. However, the clouds will not be as high as the clouds preceding a cold front. For more information, refer to the **How to Read a Satellite Image** tool
2.3	Determine the speed and direction of movement of the front. There are several ways to do this. Here is one method: 1. Locate the front on a surface chart or an IR satellite image. 2. Compare the changes in the front's location for the SAME VALID TIMES over a few days. • To determine how the different parts of the front are moving, note the relative positions of the two "ends" of the front as well as the mid point. • From the movement of the front over the time difference, calculate the rate and direction of advance for the various parts of the front. This calculation will help you determine its future position in the near term.	➢ Remember that systems do change direction and speed. However, over the near term (part of a day, for example) you can get a rough idea of how fast a system is closing on your position by watching satellite image animations and extrapolating an assumed position several hours forward.

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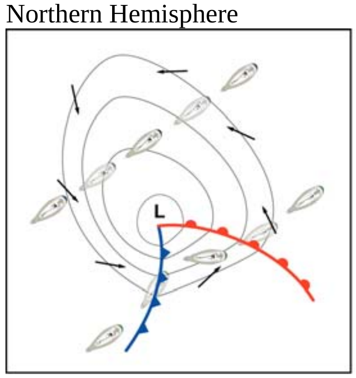
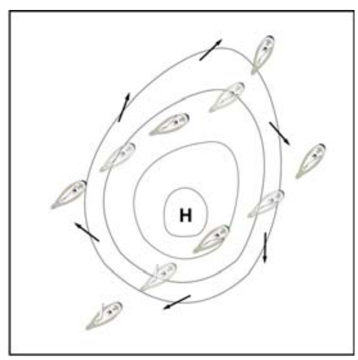
3. Determine surface wind speed and direction

Introduction:

Surface winds at the synoptic-scale are caused by differences along the pressure gradients (as indicated by the isobars on surface pressure maps) and are therefore called the "gradient wind." Gradient wind is distinguished from wind caused by local conditions. The effects of local conditions on the gradient wind will be analyzed in a later step.

Surface wind blowing across land and water causes friction. Surface friction causes the wind to turn left (in the Northern Hemisphere, right in the Southern) about 15 to 30 degrees (30 over land, 15 over water). Therefore, surface winds along the isobars in a Low will "toe-in" 15 degrees, and "toe-out" 15 degrees along the isobars of a High.

Procedure:

STEP	ACTION	EXPLANATION
3.1	Determine direction and speed of the gradient wind **from wind barbs.**	To see **Wind Barb** symbols click here.
3.2	Determine direction and speed of the gradient wind **from isobars.**	**Wind Direction**: Wind will follow the isobars. ➢ For Lows – wind will circulate in a counter-clockwise direction around that low (in the Northern Hemisphere) and be pointed 15-30 degrees in from a tangent along an isobar toward the center of the low pressure system. ➢ For Highs – wind will circulate in a clockwise direction [in the Northern Hemisphere] and be pointed 15-30 degrees away from a tangent along an isobar and away from the center of the high pressure system. Friction causes wind to blow towards a Low and away from a High, following the principle that forces always seek lower pressure. Northern Hemisphere   **Wind Speed:** Speed can be determined by the spacing of the isobars. ➢ The closer the isobars are spaced, the stronger the gradient winds. Isobars are spaced at 4 mb intervals, and labeled every 8 mb on U.S. maps. ➢ Since wind accelerates around curves, windspeed will increase around curved isobars for a given distance between isobars along the same latitude.

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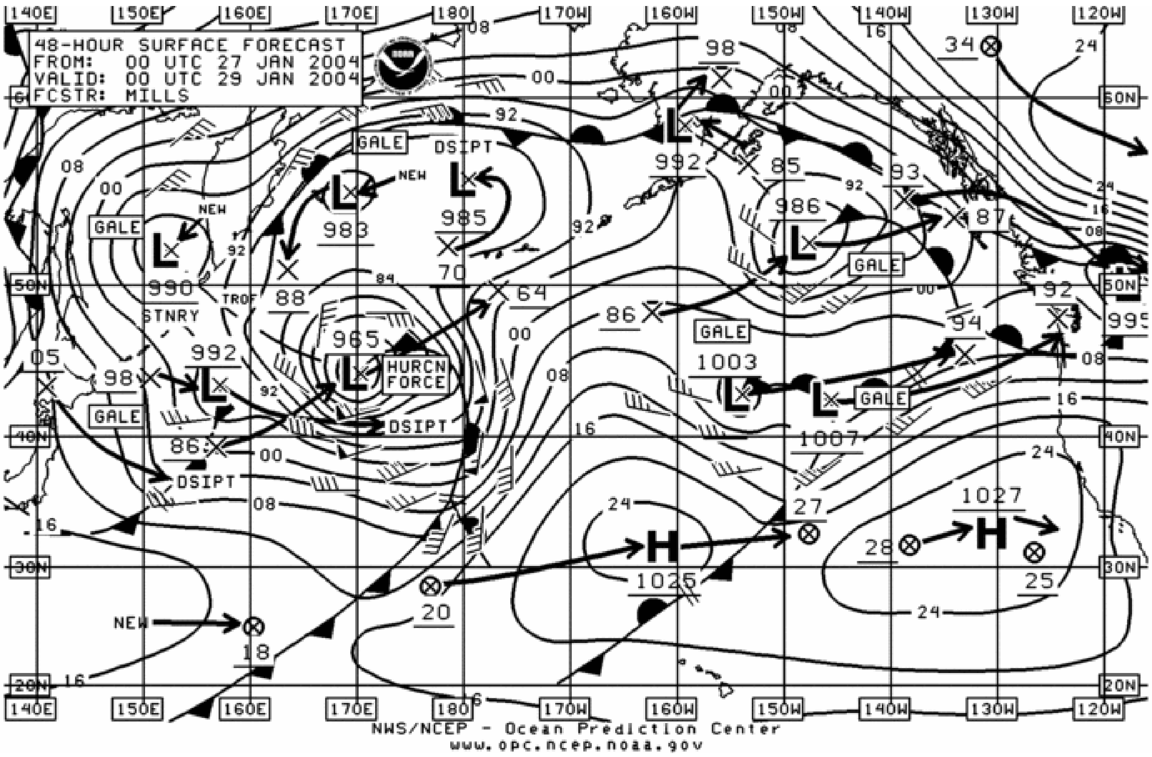
4. Determine location and characteristics of storms

Introduction:

We treat storms as a separate section in this process because the OPC provides special information on the formation and location of extra-tropical and tropical storms.



48-hr Forecast showing storm development

Procedure:

STEP	ACTION	EXPLANATION
4.1	Determine the location of **storm activity** on Surface Analysis and Forecasts Charts.	Significant weather systems have labels specifying whether the system has "gale" or "storm" conditions as observed by ship and buoy observations, Special Sensor Microwave Imagery (SSM/I), QuikSCAT, satellite, or computer model guidance. Systems having or expected to have synoptic scale "**GALE**" or "**STORM**" conditions are labeled in bold capital letters. Similarly, systems expected to develop "**GALE**" or "**STORM**" conditions in 36 hours have labels of **"DEVELOPING GALE"** or **"DEVELOPING STORM."** Surface low pressure falls of 24 mb or greater during a 24 hour period are denoted in large capital letters as **"RAPIDLY INTENSIFYING."** Areas of high winds can occur along boundary areas between very deep or fast moving low pressure systems and strong high pressure systems.

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STEP	ACTION	EXPLANATION
4.2	Locate activity of **tropical cyclones**.	➢ For **tropical cyclones**, the alphanumeric description of the analyses or forecast time is displayed in bold capital letters adjacent to the tropical cyclone's position with the appropriate cyclone symbol. • TYPHOON or HURRICANE or TROPICAL STORM "NAME" • LATITUDE ___ LONGITUDE • MAX WINDS___ KT G (GUST) ___KT ___ • MOV DIR ___ (DEGREES) AT __KT ➢ A 24-hour tropical cyclone symbol forecast position will be depicted on all surface analyses. ➢ Both 24-hour and 72-hour tropical cyclone positions will appear on the 48-hour surface forecasts.
4.3	If the Surface Analysis Charts indicate a tropical storm, consult the appropriate tropical prediction center's charts**.**	➢ Tropical Prediction Center's (TPC) National Hurricane Center (NHC) covers the Atlantic and the Eastern Pacific Oceans east of 140W. ➢ The Central Pacific Hurricane Warning Center (PHNL) covers the Eastern and Central Pacific Ocean west of 140W to the international dateline (180). ➢ The Joint Typhoon Warning Center (JTWC) covers the Western Pacific west of 180.

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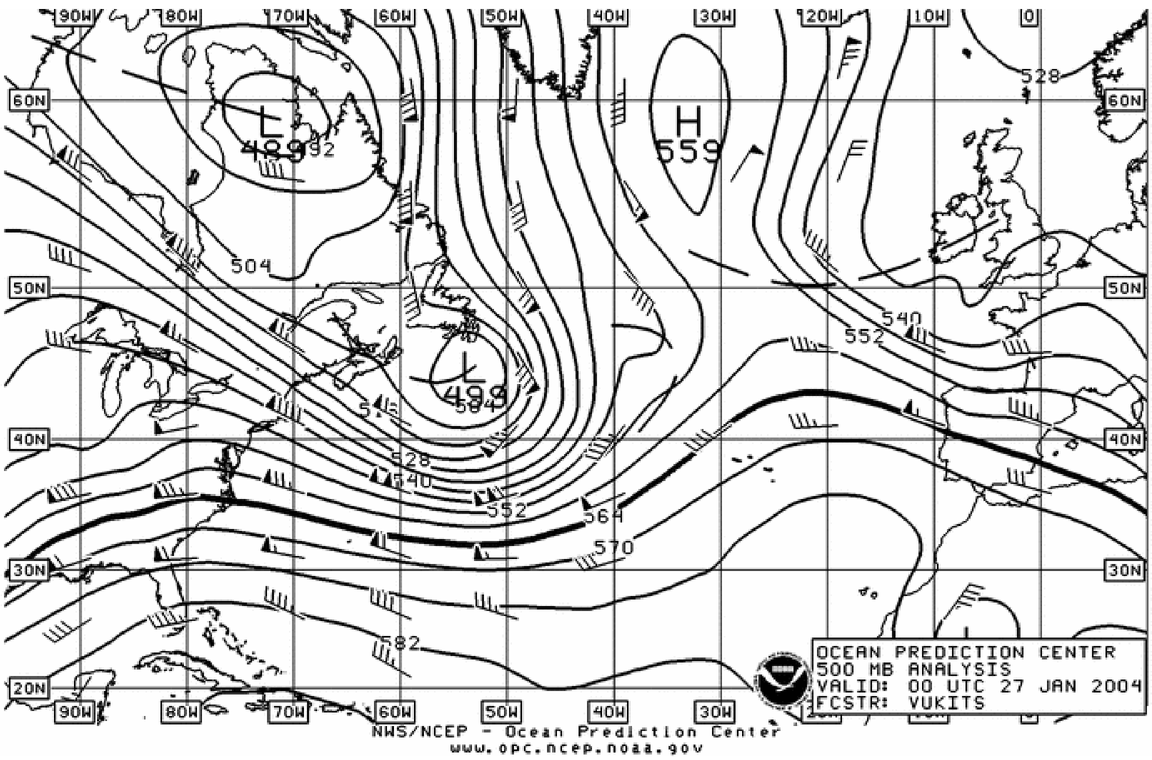
5. Compare surface pressure charts with upper atmosphere (500 mb) charts

Introduction:

If you are sailing in the temperate latitudes, the **jet stream** is an important feature in determining the activity of surface weather. A 500 mb chart, which shows weather activity in the upper atmosphere, can help determine the movement of surface pressure systems, especially extra-tropical L pressure systems.

For a **comparison** of surface weather maps and 500 mb maps, refer to the [Surface vs 500mb Maps] tool.

For more **detailed information** on 500mb charts, refer to the document: [Mariners_Guide_to_500_mb_charts_res.pdf].



Example of 500 mb Analysis Chart

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Procedure:

STEP	ACTION	EXPLANATION
5.1	Locate the **jet stream**.	➢ In the **summer** (including late spring and early fall), the jet stream is a band located near the **564** and **570** meter contours. ➢ In the **winter** (including late fall and early spring), it is associated with the **546** and **552**-meter contours. ➢ These bands are widely used by the sailors for general surface storm track direction and the southern extent of Beaufort Force 7 (28-33 knot) or greater surface winds in the winter, and force 6 (22-27 knot) winds in summer. ➢ The jet stream can help determine where surface **L pressure systems are located**. L pressure systems often travel 300 to 600 nm (5-10 degrees of latitude) north of the 564-meter contour (storm track). ➢ Exceptions include cut-off lows (see below).
5.2	Determine the jet stream's **energy potential**.	➢ The **narrower the band** (jet stream) between the ridges, the faster and greater potential energy of L pressure system. ➢ The **wider the band**, the slower and less potential energy.
5.3	Identify upper atmosphere **ridges** and **troughs**.	➢ Troughs are elongations extending out from L pressure systems. They are sometimes indicated on upper atmosphere charts as **bold, dashed lines.** ➢ Ridges are elongated portions extending out from H pressure systems.
5.4	Determine the probable location of **surface** L and H pressure systems based on upper atmosphere ridges and troughs.	➢ **Troughs:** Northern Hemisphere surface L pressure systems are found on the south or east side of an upper level trough (never on the west side). ➢ **Ridges**: Northern Hemisphere surface H pressure systems are found on the south or east side of an upper level ridgeline.
5.5	Determine the amount of **amplitude** in the system (the North/South extension of a ridge or trough). Cold is air is transported South by the upper-level jet stream and entrained with warm air being brought up to the North. The greater the North/South extension, the stronger the effects on surface weather.	➢ **High amplitude** (large wave contours) can cause surface systems to be slow-moving and strong. ➢ **Low amplitude** (flat, parallel contours) can cause surface systems to be fast-moving and weak.

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STEP	ACTION	EXPLANATION
5.6	Look at the **structure** (“tilt”) of the amplitude.	➢ **Positive tilt** (oriented easterly as it points toward the pole) can cause surface systems to be fast-moving and weak. ➢ **Negative tilt** (oriented westerly as it points twards the pole) can cause surface systems to be slow-moving and strong.
5.7	Look for **blocking ridges**.	➢ **Blocking ridges** can slow the progress of surface Lows and direct them toward the poles. ➢ However, if amplified sufficiently, the Low may try to dip toward the equator.
5.8	Look for **cut-off lows**. If a trough is sufficiently amplified, an upper level Low may develop on the equator side of the jet stream. If the jet stream recedes back toward the pole, it can leave the low “cut off” from the flow of the jet stream.	➢ Cut-off lows can remain in one location for an extended period of time because they lack the guiding force of the jet stream, causing the surface system to persist for days or perhaps a week or more. ➢ Winds can be stronger than normal and from atypical directions. ➢ Cut-off lows tend to form during the spring and summer when the jet stream is on the move (migrating north or south for the season).
5.9	From the jet stream wind barbs, **estimate surface speeds**.	➢ **Surface pressure systems** travel at between 25% and 50% of the jet stream speed as a rough rule of thumb. ➢ **Surface wind speeds are** about 40% of the jet stream speed as a rough rule of thumb.

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6. Determine the reliability of the forecast charts

Introduction:

This is a recommended step if you are cruising or racing offshore for multiple days. Within the 96-hr (4-day) window prior to your departure, determine the reliability and accuracy of the forecasts (and forecasters) that you will be using for your planning and voyage. This step will indicate if there is some doubt about the forecast reliability.

Procedure:

STEP	ACTION	EXPLANATION
6.1	Begin collecting the 96-hr forecasts with Valid Time that's close to the time of your planned departure. As you continue to collect them over the next few days, also collect the 48-hr forecast chart two days after your first 96-hr forecast. Compare the 48-hr and 2-day old 96-hr surface forecasts for the same Valid Times.	➢ They should look the same. If there are differences, it would imply some vagueness about what is about to occur in 2 days' time, and may create doubt about the reliability of either the 96-hr or the 48-hr chart.
6.2	Collect the 24-hr forecast chart the day before your departure. Compare both the 96-hr and 48-hr charts with the 24-hr forecast for the same valid time	➢ They should look the same. If not, there may be vagueness about what is going to occur in the next 24 hours, and may raise doubts about the reliability of one or more of the charts.
6.3	Collect the surface analysis on the day of your departure. Compare the 96-hr, 48-hr, and 24-hr charts with the current surface analysis chart for the same valid times.	➢ They should look the same. You can assume a higher degree of reliability in the current surface analysis, since it states current, not forecasted, conditions based on actual observations.
6.4	If these comparisons raised reliability issues with the charts you used, compare the surface analysis charts with other data as the valid time draws near, such as: • computer models • other forecast charts • scatterometer data • IR satellite images	➢ Note how the highs and lows are expected to move and evolve in each of the forecasts, giving more weight to the forecasts that are the most current. You may be able to identify one or more "suspect" forecast products.

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