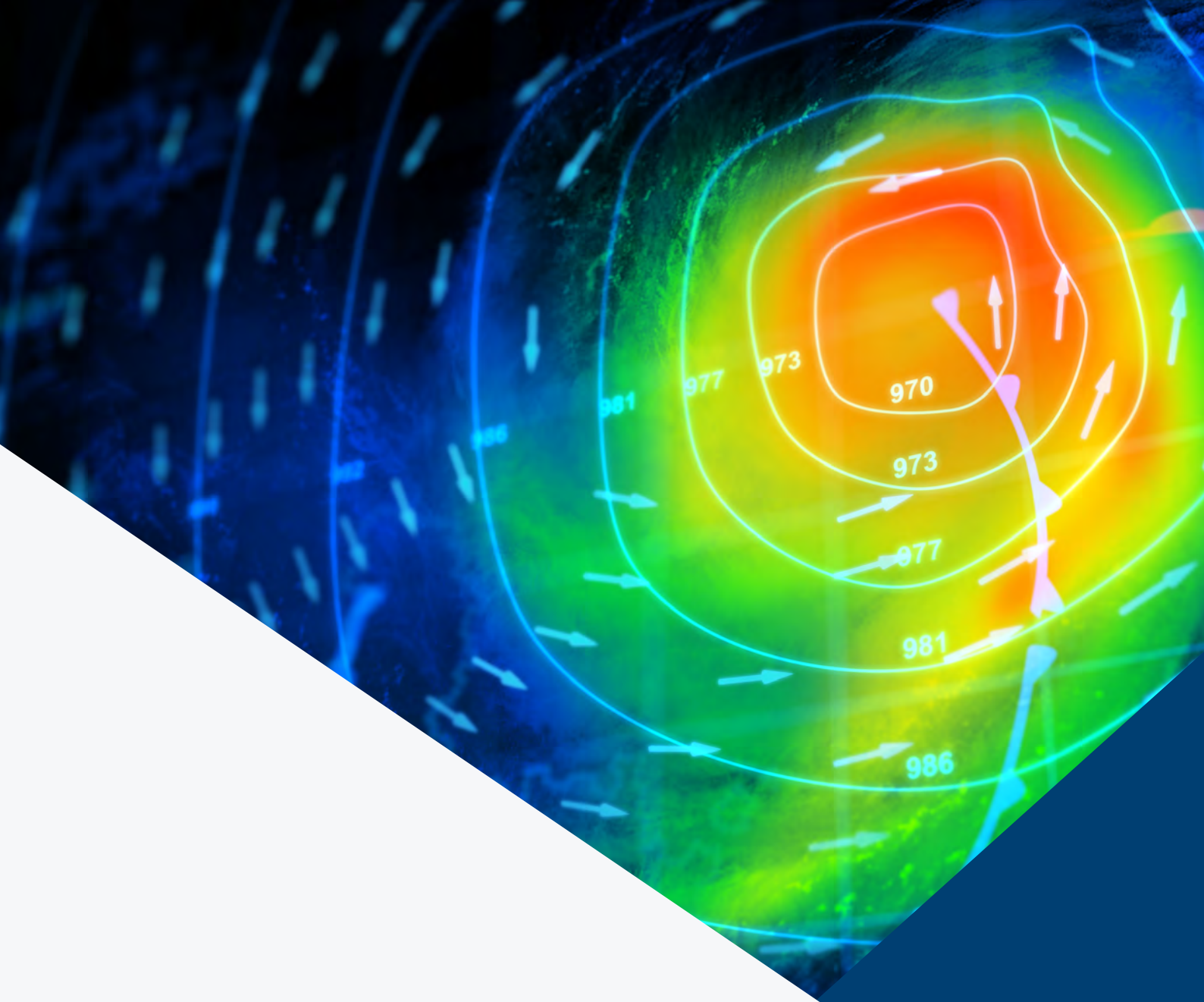




OCEAN RACING CLUB OF VICTORIA

WEATHER FOR SAILORS

MODULE 3 - TRANS OCEANIC (KNOWLEDGE)

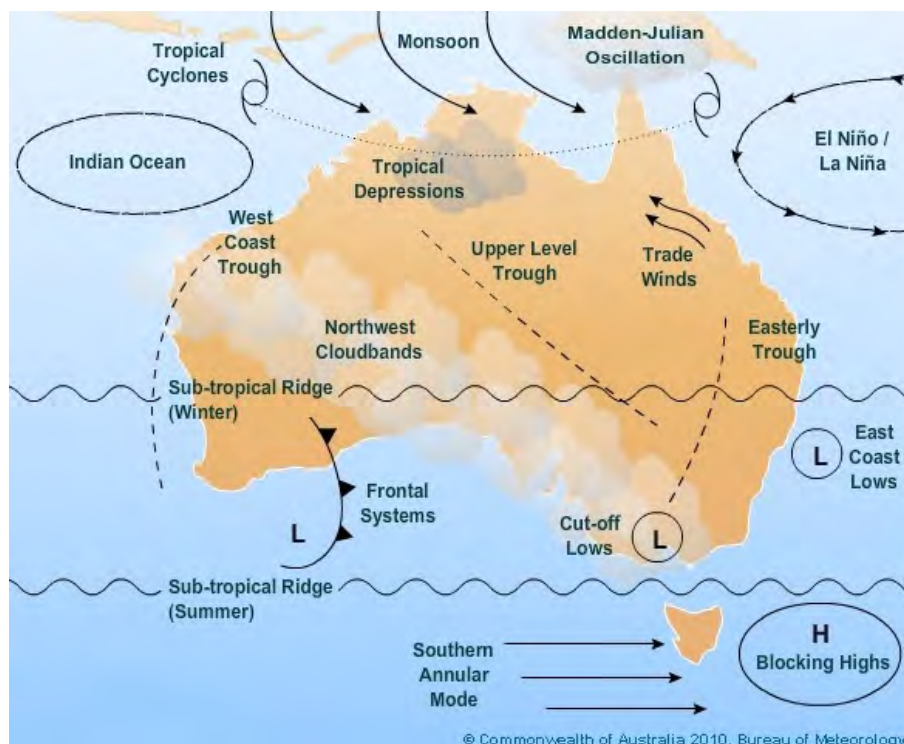
Weather for Sailors – Module 3, Trans Ocean

This course has been developed not only for sailors interested in sailing to or planning for an extended international voyage, but also for practical students of weather and for those sailing extended periods well offshore. There is an explosion of science occurring with weather, bringing huge benefits in predictability and understanding. Much of this will require an awareness of the terminology and concepts involved with the science in order to better use the information to our advantage. The various worldwide meteorological bureaus now present their products in ever better formats for our usage but with awareness we can utilize so much more. Therefore, the course avoids formulae or proofs in favour of better understanding the kind of reports available to assist us on the water or before venturing. Planning for the sailing adventure of a lifetime is a drawn-out process encompassing boat and crew preparation, paperwork (customs etc) and victualling as well as weather. As always, being prepared with a broad plan is not just about route investigation but also contingencies. There is plenty of history giving weather averages for planning but unusual events also occur and need to be planned for as well. This session will examine planning tools and conditions which could be encountered in an extended voyage. As usual, ORCV events have a series of information seminars to assist in an organized event but reality is that each vessel has to rely on its own capabilities, limitations and resources.

Initial weather planning.

Seasonal Variation of pressure belts such as the Westerlies, Southern High Pressure zone and the Inter-tropical convergence zone (ITCZ) is a first guide for planning as an indication of timing for climate conditions as background information. Cyclone seasons in both North and South hemispheres can indicate where not to be and when to not be there.

BOM video Understanding the Southern Annular Mode (SAM)
<https://www.youtube.com/watch?v=KrhWsXCB3u8>

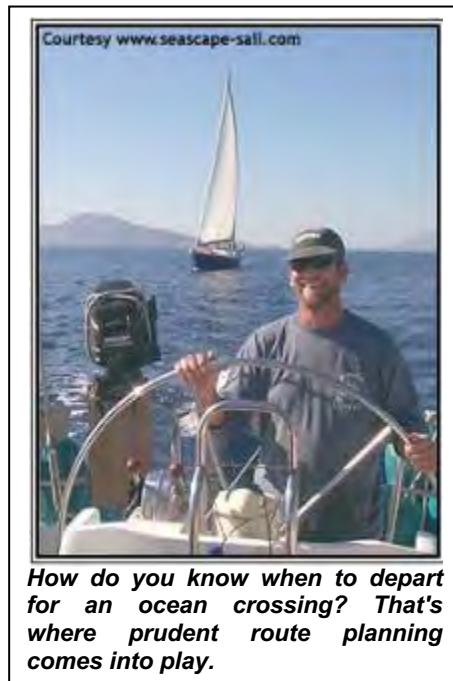


Route Planning 101 Michael Carr 2004

Consider this question: When do you depart on a voyage? Do you do it when the crew is ready? Do you make that decision based upon when the boat is ready? Or when you, the captain, are ready? Or maybe you just depart because the boat anchored nearby is weighing anchor so it must be time to go.

Some boats travel solo and others travel in rallies, going en masse. So how do sailors following these diverse modes of travel resolve the go or no-go decision as well as the multitude of issues involved in choosing a proposed track and then either staying with that track or modifying it as circumstances and conditions change? These are fundamental questions for all ocean-going sailors.

At first it might seem that there is no way to come to a logical and reasoned decision. But there actually is and the first step is to define your objective. Are you departing on a race that you highly desire to win or are you heading off on your first ocean cruise? You must define the objective for your voyage. Saying "I want to safely cross the Atlantic Ocean and minimize my exposure to gale-force winds" is something quite different than "I want to enter the Around Alone Race and win." These two very different goals have both issued forth from my mouth in the past, so I know something about this topic.



When a person cannot make intelligent decisions, he or she usually ends up guessing, and that introduces chance into the decision-making process, which can lead to disastrous mistakes.

Once you have articulated the object of your voyage, you can then define the type of weather you desire to experience. In saying weather I include wind, waves, ocean currents, fog, rain, low and high-pressure systems, and tropical events. Waves are probably the most critical weather element since they have the greatest potential effect on a vessel's stability and its ability to make progress toward a given destination.

Weather window is the term usually applied to that period of time, which can be hours or days, during which weather elements are appropriate for a specific, selected transit, having considered the vessel and crew's capabilities and constraints. Accepting this definition of a weather window confirms that there is no universal weather window for all voyages, boats, and crews.

Here's an example: The appropriate weather scenario for a record-setting run west-to-east across the Atlantic on a catamaran is not necessarily the same weather situation you'd want for sailing a cruising monohull over the same course. A record-racing catamaran crew would desire strong, low-pressure systems that move with it at speeds of 20 to 30 knots, while the crew of a cruising boat would rather have a stationary high-pressure system providing consistent and steady winds. For a multihull, the strong southerlies and southwesterlies that



precede the arrival of low-pressure system in the Northern Hemisphere would favor the cat's off-the-wind reaching prowess—allowing it to achieve speeds equal to and greater than the true wind. A slower moving cruiser would prefer the same wind direction, southerly, but at a lesser and more consistent strength, which is gained by using winds coming off the Bermuda-Azores high pressure instead of the winds associated with developing and growing low-pressure systems.

Once a crew has chosen a route and departed, the skipper shouldn't consider that the route is locked in place. It must be updated and tweaked daily, hourly, and often minute-by-minute in response to changing weather, vessel, and crew conditions. A chosen route is similar to the information contained in a AAA triptick in that it is for general guidance only. You still need to watch the traffic pattern, shift lanes to avoid unnecessary traffic, and even detour if conditions become unacceptable. For ocean-going sailors, the same kind of flexibility is key—a willingness to institute and make changes.

Although it's very often overlooked, crew fatigue is one of the most important factors in determining a route. A human body has definite limits. Sleep must be given to a tired body; lack of sleep causes numerous mental and physical problems. A tired person does not think effectively, his ability to evaluate and process information is significantly slowed and events can easily overwhelm such a person. When a person cannot make intelligent decisions, he or she usually ends up guessing. Guessing introduces chance into the decision-making process, and so mistakes are made. Sometimes such mistakes are simple and not too dangerous, but other times those mistakes can cause injury to the boat or crew, or worse.

This is why all decisions need to be made within the context of a crew's capabilities, taking into account their physical and mental condition, their experience, their training, as well as their level of fatigue. A tired crew cannot perform, and should not be made to perform. In a sense, routing is a study in situational awareness, of knowing your long-term objectives while maintaining a grasp on your immediate surroundings. It is also a challenge in observing, detecting, analyzing, and then acting as you observe and evaluate your weather, crew, and vessel.

So, now that we know all the variables and possibilities, how do we start the routing process? First consider the following initial track options:

Great Circle - The shortest physical distance over a curved surface.

Rhumblines A course that crosses all longitudes at the same angle, but is not the shortest physical distance across a curved surface.

Bucket A route that forms the shape of a bucket by taking the vessel north or south until reaching a desired latitude for passage, then perpendicular until near the longitude of the destination whereafter the vessel turns north or south to the destination. Sailors utilize this form of routing to minimize exposure to weather at unsuitable latitudes.

Composite A hybrid of the great circle and rhumblines routes, the composite approach employs a limiting latitude so that sailors can avoid unsuitable weather or restrictions due to geography, ice, or political constraints.

Once you choose the best route option you can then begin factoring in crew and vessel capabilities and limitations. Always remember that on ocean voyages, both long and short, the route that will take the least time to sail is very often not the shortest physical route. Unlike the AAA triptick, you cannot depend on making a steady speed nor have a flat highway for an entire passage at sea.



Savvy sailors know to adapt their route planning to accommodate the many changes in weather and oceanographic conditions once underway.

To manage your route you need information, the kind of information that keeps you informed of past, present, and future weather and oceanographic conditions. Without information you cannot make intelligent routing decisions, especially in the dynamic environment of weather. To gather information you need systems that bring in quantities of quality and timely information. Last week's weather chart is of little use, as is today's weather chart if it contains scant information. You want weather products that are data-intensive with quality data.

OK, where do such products come from? These days the Internet is overflowing with quality weather data, and marine weather products are supplied through a number of communications systems. Some that you should be aware of are NAVTEX, Inmarsat C Safety Net, OCENS

Millennium, Iridium, GlobalStar, Inmarsat A, B, M, and the Global Maritime Distress and Safety System (GMDSS). Technology advances rapidly and so does obsolescence-always check!

A final element in successful route planning is having access to emergency communications should you need to request assistance. An emergency position indicating beacon (EPIRB), or a GPS equipped EPIRB (GEPIRB) should be mandatory equipment for every ocean-going vessel. And I consider it necessary to carry a search and rescue transponder (SART) and an emergency VHF radio, as well as immersion suits for protection from hypothermia, a liferaft, and a watermaker. Humans can survive an amazing amount of time without food, but freshwater is another matter. It's imperative that the human body intake at least 18 ounces of water every day to maintain a basic level of function. So, even the best life raft and emergency-locating gear won't guarantee that you will be alive when help arrives. You need to keep yourself hydrated and warm.

Follow these prescriptions regarding routing and make decisions only after you've gathered all the information that you can. Do that and you should be able to make the most of any offshore passage.



Having access to multiple means of communication in an emergency is an important part of successful route planning says the author.

Planning tools

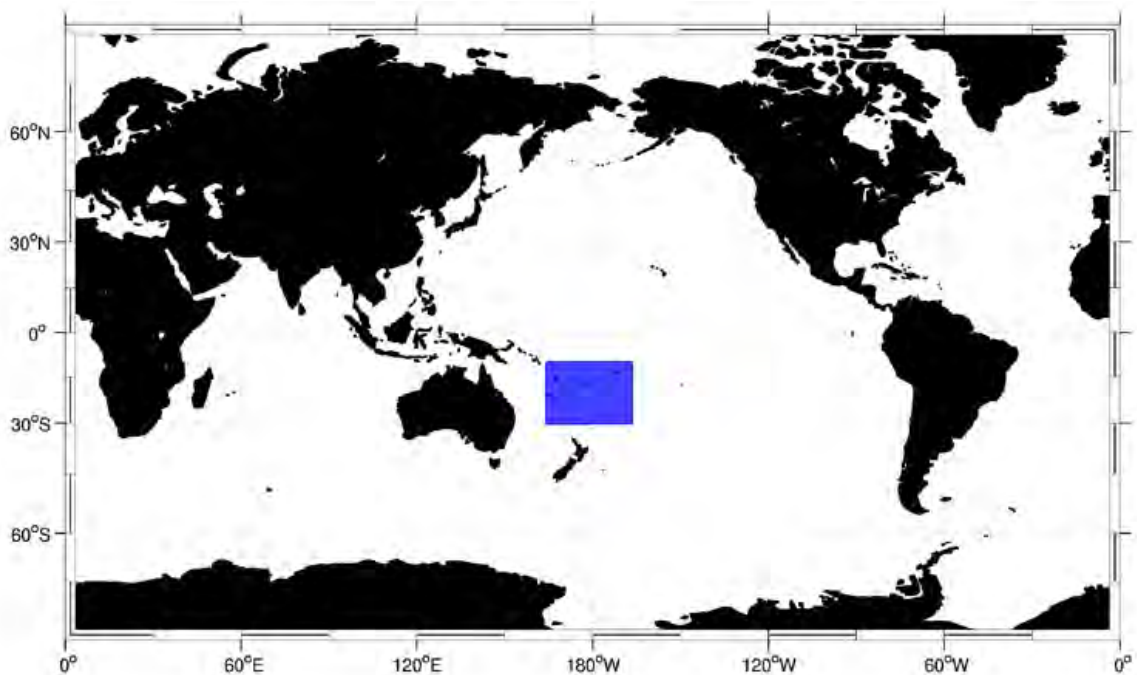
There are a number of resources available including Pilot publications, Admiralty Sailing Directions and Ocean Passages of the World which has *wind roses* (see below) but generalized in fairly large areas. Far more detail can be gained from a web site tool headlined COGOW (Climatology of global ocean winds). This site utilizes information from satellite technology and can give data in ½degree lat/long breakdown as a selection plus broadscale graphically notated areas. Examples follow.



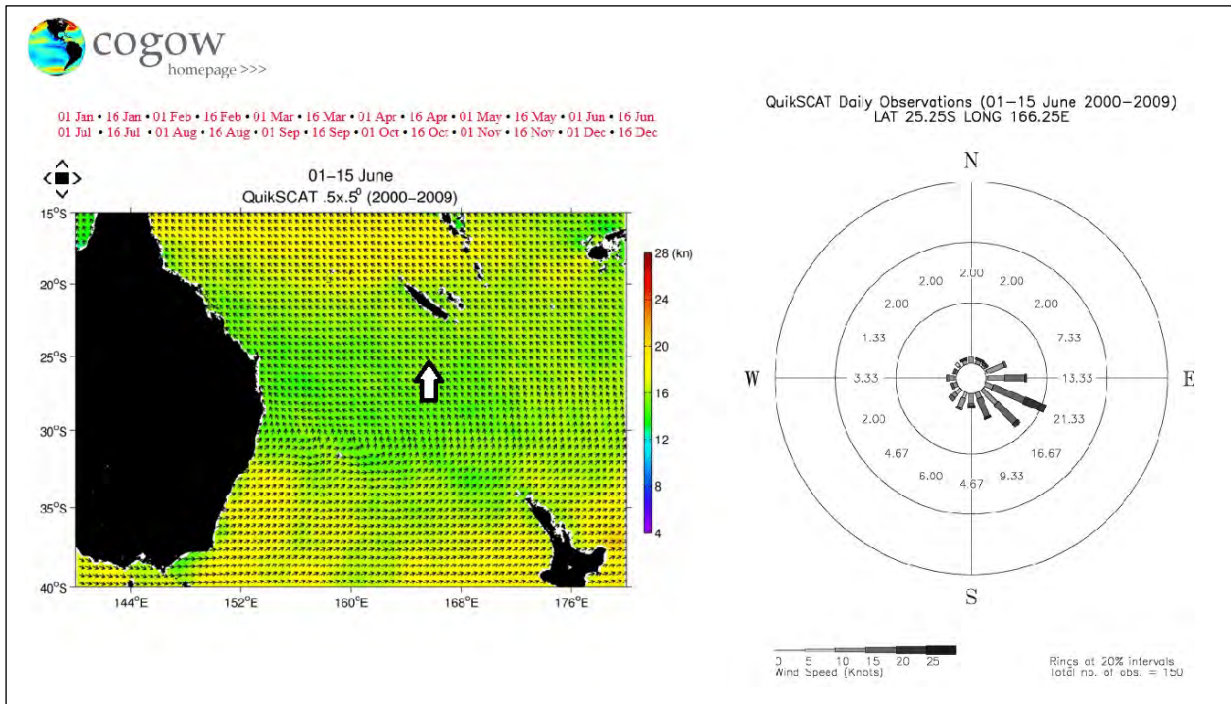
<http://cioss.coas.oregonstate.edu/cogow>

Cogow URL resource for wind information as indicator, a useful tool but only a guide

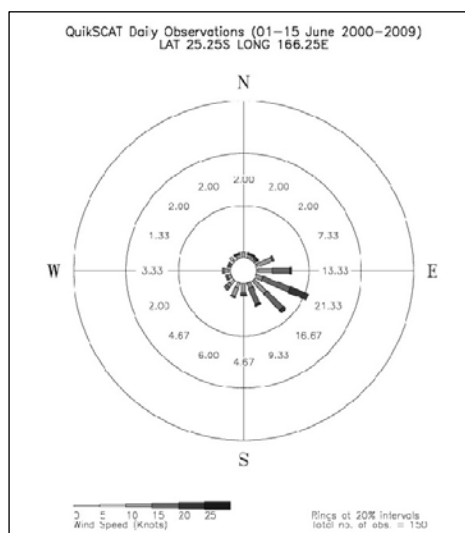
Example results follow. Note a user manual in the opening page, select Cogow ver 1 Area select, move the purple rectangle near the area of interest and click.



When the purple rectangle is clicked, a large scale area will display, if not what is desired go back and move the purple rectangle closer to your desired location. From the broadscale wind diagram select the time period above the chart for the half month period of proposed voyage and then click the location of the 1st. area along your proposed route to obtain a wind rose.



to assemble route information. Above the broadscale diagram is a four-way move tool which by pressing a suitable direction arrow will move your selection.



Note that the broadscale diagram gives wind averages. Selecting a desired point of interest brings up a windrose . One needs to consider the possible minor barbs in planning. We have all heard it before! “This weather is unusual!”. Just my luck to be here during the minor weather barb.

Wind roses summarize the occurrence of overlapping 3-day average winds within a 0.5 latitude by 0.5° longitude bin centered at 25.255°S, 166.26°E showing their strength, direction and relative frequency. The wind Rose is interpreted as follows: the length of the barbs that extend radially from the centre of the rose, reflect each direction's relative frequency. If the barb pointing from the ESE is twice as long as the barb pointing from the SSE then the winds blew FROM the ESE twice as frequently as they did from the SSE. In

each direction, the barb's appearance varies through several styles in sequence. The proportion of the barb's length in each style indicates the proportion of time winds blew from that direction at a given speed. For example, a thin, light grey rectangle extending from the centre indicates wind speeds of between 0 and 5 knots. A slightly thicker, and slightly darker grey, segment indicates wind speeds of between 5 and 10 knots, and so forth until, finally, a thick black rectangle indicates wind speeds greater than 25 knots. To aid with interpretation, concentric rings at 20 % frequency intervals are plotted on each wind rose. Additionally, the

total number of overlapping 3-day average observations used to create each wind rose is included in the lower right-hand-corner of each plot. And do not forget to examine the timing and route for the trip home or to formulate a lay-over until the timing is more feasible. The COGOW tool enables this process. Of course there are other climate factors which can increase or decrease the averages obtained.

Climate influencers

ENSO and IOD are major climate drivers which affect sailing conditions particularly in the Southern Hemisphere due to the mainly ocean covered areas and compared to the more land covered Northern Hemisphere. The Australian Bureau of Meteorology monitors several indicators and produces indices in order to determine the current status and outlook for our area of interest.

An index is a measure (often a numerical value) that can be representative of a particular pattern or state of a system. Climatologists monitor several indices, some ocean-based and some atmospheric, to provide a quick indication of the state of certain climate variables and climate drivers.

El Niño–Southern Oscillation indices

El Niño and La Niña events (collectively referred to as the El Niño–Southern Oscillation or ENSO) are driven by changes in the equatorial Pacific Ocean. During El Niño, sea surface temperatures in the central and eastern Pacific Ocean become warmer than average, while La Niña is characterised by cooler than average sea surface temperatures in the same regions.

In order to monitor the Pacific Ocean for signs of El Niño or La Niña, climatologists use several sea surface temperature (SST) indices. These indices simply refer to the difference from the long-term (1961–1990) mean of the sea surface temperature in several regions located along the equatorial Pacific. These regions are called NINO1 and NINO2 (which lie on the South American coast), NINO3, and NINO3.4 (which occupy the eastern and central equatorial Pacific respectively) and NINO4 (located in the western Pacific). NINO3.4 partially overlaps both the NINO3 and NINO4 regions.

The NINO regions (see map below) cover the following areas:

- NINO1: 5-10°S, 80-90°W
- NINO2: 0-5°S, 80-90°W
- NINO3: 5°N-5°S, 150-90°W
- NINO3.4: 5°N-5°S, 120-170°W
- NINO4: 5°N-5°S, 160°E-150°W

For monitoring of ENSO events, the value of the NINO indices are often used in conjunction with other data, e.g., sub-surface ocean temperatures, cloudiness, winds, and the Southern Oscillation Index (SOI). Australian climatologists often cite sustained monthly NINO3 or NINO3.4 values above +0.8 °C as typical of El Niño conditions, with values of below –0.8 °C as that of La Niña. These values are approximately one standard deviation from the long-term mean (i.e., around 70% of monthly NINO3 values, for example, lie between –0.8 °C and +0.8 °C).

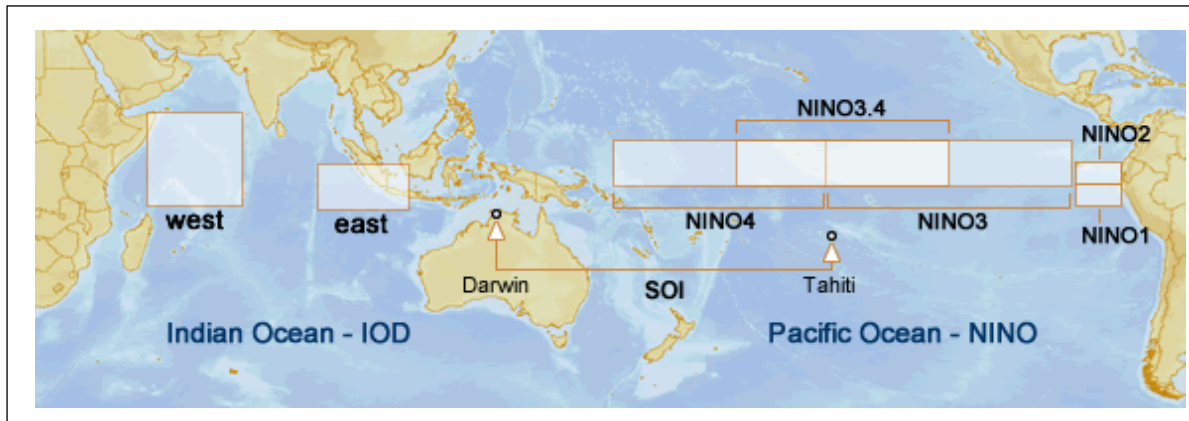


Figure 1 Regions used to monitor ENSO and IOD. The NINO regions are used to monitor ENSO, with NINO3 and NINO3.4 typically used to identify El Niño and La Niña events. The IOD index (or Dipole Mode Index, DMI) is used to identify IOD events, by taking the difference between the west and east poles.

The Indian Ocean Dipole indices

Indian Ocean Dipole (IOD) events are driven by changes in the tropical Indian Ocean. Sustained changes in the difference between normal sea surface temperatures in the tropical western and eastern Indian Ocean are what characterise IOD events.

The IOD is commonly measured by an index (sometimes referred to as the Dipole Mode Index, or DMI) that is the difference between sea surface temperature (SST) anomalies in two regions of the tropical Indian Ocean (see map above):

- IOD west: 50°E to 70°E and 10°S to 10°N
- IOD east: 90°E to 110°E and 10°S to 0°S

A positive IOD period is characterised by cooler than average water in the tropical eastern Indian Ocean and warmer than average water in the tropical western Indian Ocean. Conversely, a negative IOD period is characterised by warmer than average water in the tropical eastern Indian Ocean and cooler than average water in the tropical western Indian Ocean.

For monitoring the IOD, Australian climatologists consider sustained values above +0.4 °C as typical of a positive IOD, and values below −0.4 °C as typical of a negative IOD.

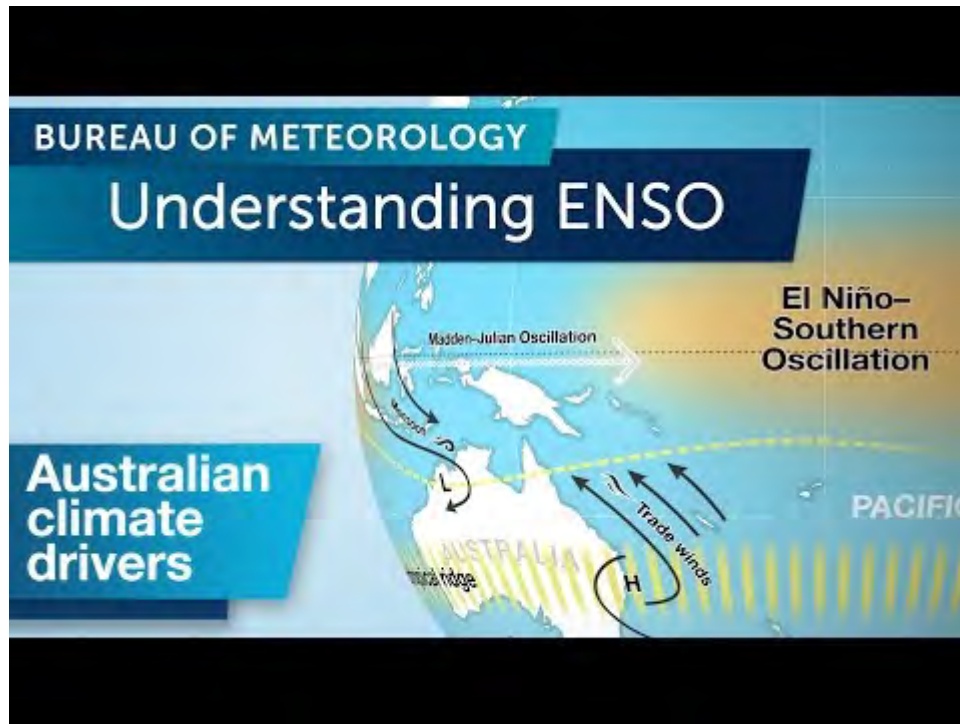
ENSO and IOD outlooks

The Bureau produces long-range sea surface temperature outlooks for the NINO and IOD regions, to provide information on the potential development of El Niño, La Niña or IOD events in the coming months. The main regions focussed on are the NINO3.4 index and the IOD index as these are used to help identify ENSO and IOD events, respectively. A summary of the ENSO and IOD forecasts from international climate models is also produced.

El Niño Southern Oscillation (ENSO)

ENSO is the oscillation between El Niño and La Niña conditions.

This climate influence is related to: [El Niño](#) [La Niña](#) [The Australian Monsoon](#)



[Video:](#)

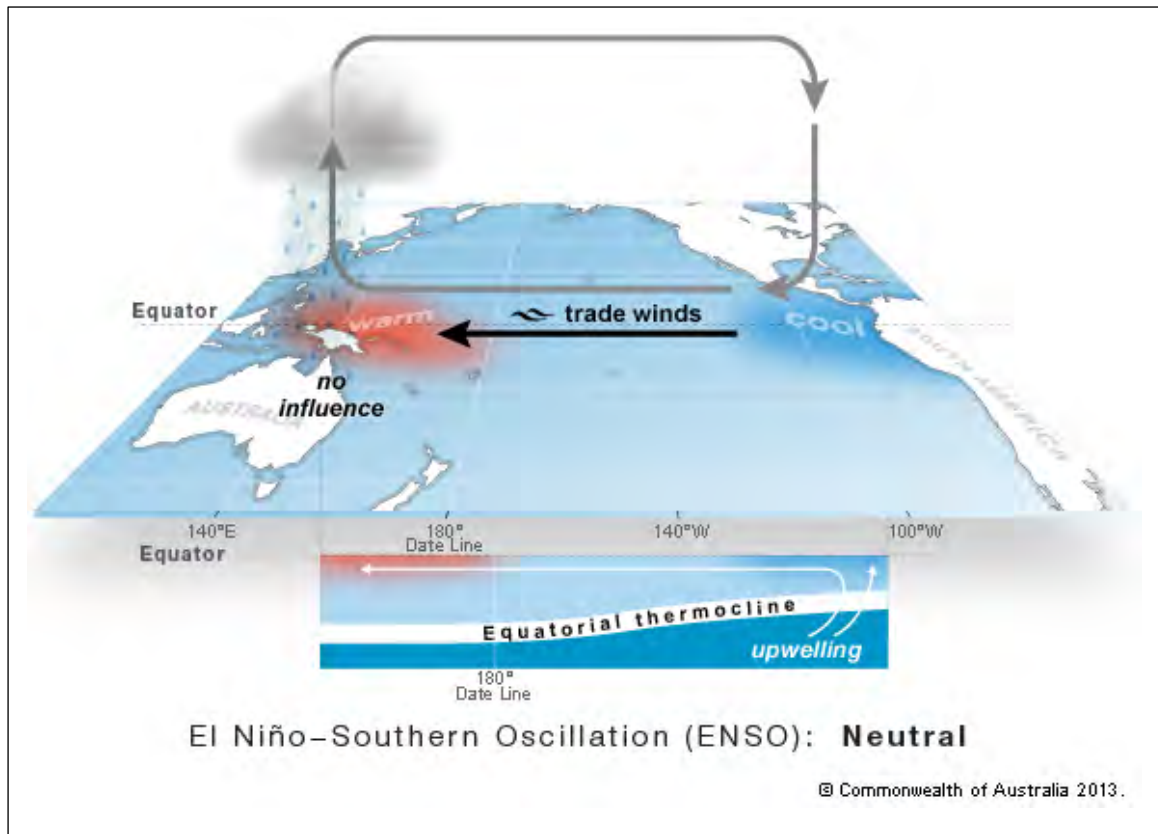
Understanding ENSO <https://www.youtube.com/watch?v=dzat16LMtQk>

The term El Niño refers to the extensive warming of the central and eastern tropical Pacific Ocean which leads to a major shift in weather patterns across the Pacific. This occurs every three to eight years and is associated with a weaker [Walker Circulation](#) (see diagram below) and drier conditions in eastern Australia. El Niño Southern Oscillation (ENSO) is the term used to describe the oscillation between the El Niño phase and the La Niña, or opposite, phase.

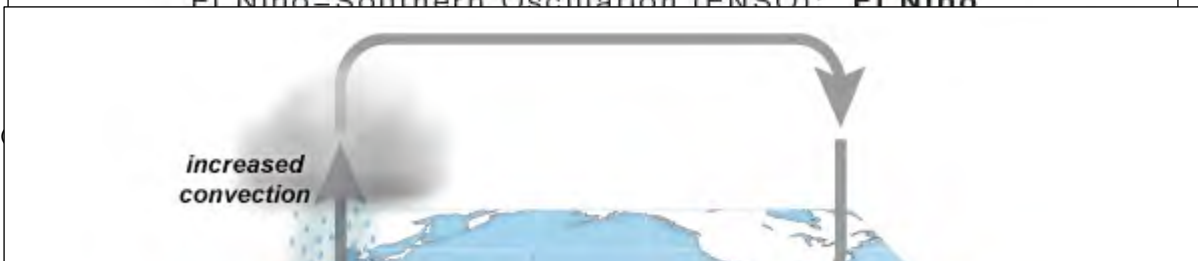
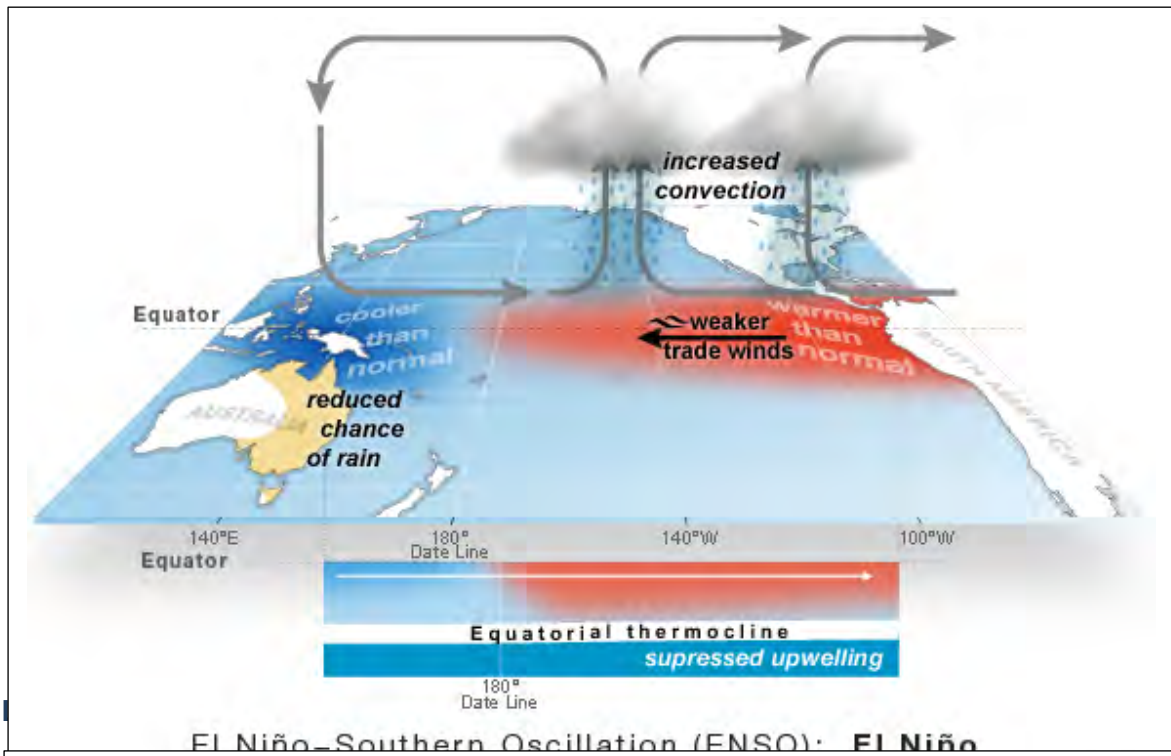
In the eastern Pacific, the northward flowing Humbolt current near south America brings cooler water from the Southern Ocean to the tropics. Furthermore, along the equator, strong east to south-easterly Trade winds cause the ocean currents in the eastern Pacific to draw water from the deeper ocean towards the surface, helping to keep the surface cool. However in the far western Pacific there is no cool current, and weaker Trades mean that this "upwelling" effect is reduced. Hence waters in the western equatorial Pacific are able to warm more effectively under the influence of the tropical sun. This means that under "normal" conditions the western tropical Pacific is 8 to 10°C warmer than the eastern tropical Pacific. While the ocean surface north and northeast of Australia is typically 28 to 30°C or warmer, near South America the Pacific Ocean is close to 20°C. This warmer area of ocean is a source for convection and is associated with cloudiness and rainfall.

However, during El Niño years, the trade winds weaken and the central and eastern tropical Pacific warms up. This change in ocean temperature sees a shift in cloudiness and rainfall from the western to the central tropical Pacific Ocean.

ENSO neutral



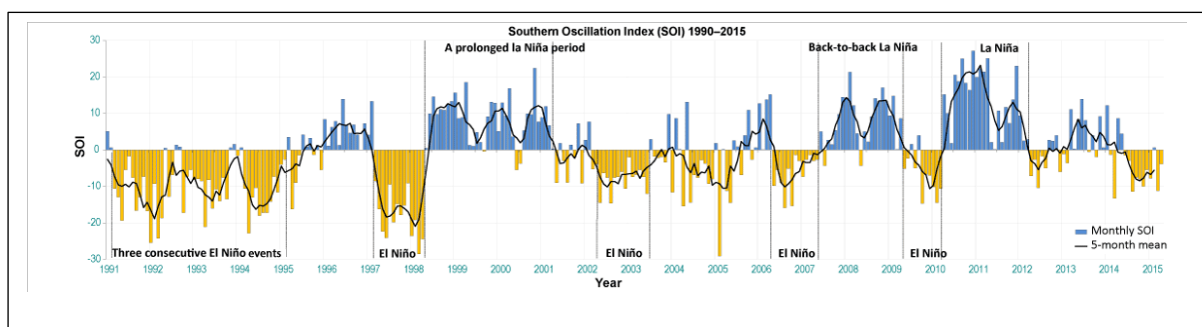
El Niño



La Niña

The Southern Oscillation Index, or SOI, gives an indication of the development and intensity of El Niño or La Niña events in the Pacific Ocean. The SOI is calculated using the pressure differences between Tahiti and Darwin. The following figure demonstrates the typical fluctuations in SOI over a period of 11 years. Positive SOI values are shown in blue, with negative in orange. Sustained positive values are indicative of La Niña conditions, and sustained negative values indicative of El Niño conditions.

This graph shows the values of the SOI between 1991 and mid-2015. [Monthly SOI data.](#)



How does it affect Australia?

Each phase of the ENSO has a very different effect on the Australian climate. Events generally have an autumn to autumn pattern of evolution and decay. That is, they typically begin to develop during autumn, strengthen in winter/spring, then decay during summer and autumn of the following year.

During a La Niña event, the Walker Circulation intensifies with greater convection over the western Pacific and stronger trade winds. As the trade winds strengthen, the pool of warmer water is confined to the far western tropical Pacific, resulting in warmer than usual sea surface temperatures in the region north of Australia. Sea surface temperatures across the central and eastern tropical Pacific Ocean become cooler than usual and the thermocline moves closer to the surface – cool waters from the deep ocean are drawn to the surface as upwelling strengthens. Convection and hence cloudiness over the region north of Australia increases as stronger winds provide more moisture to the overlying atmosphere and the Walker Circulation intensifies.

La Niña likely to continue until at least the end of summer 2020–21

La Niña continues in the tropical Pacific. Australian and international climate models suggest it is likely to continue at least into February 2021.

Central and eastern tropical Pacific Ocean sea surface temperatures remain at La Niña levels, as do most atmospheric indicators, including trade winds and cloudiness. The Southern Oscillation Index (SOI) has moved back into neutral values, most likely due to the influence of a passing MJO event. The SOI is expected to return to La Niña levels in the coming weeks.

La Niña typically increases the chance of above average rainfall across much of Australia during spring, and across eastern Australia during summer. Current climate outlooks indicate rainfall during November 2020 to January 2021 is likely to be above average for most of the country.

Most models suggest La Niña will peak in December, with around half the models anticipating a strong event. While there is some possibility that the peak strength could reach levels similar to 2010–12 there are some differences. La Niña became established much earlier in 2010, was long lived (over two years), and impacts were enhanced by a negative Indian Ocean Dipole and warm ocean temperatures around Australia.

In contrast, the Indian Ocean Dipole (IOD) is currently neutral, and most models suggest it will remain neutral for the rest of 2020.

The Southern Annular Mode (SAM) is expected to be positive for the remainder of October into early November. La Niña tends to favour positive SAM during spring and summer, further supporting the likelihood of above average rainfall in the east.

The Madden–Julian Oscillation (MJO) is currently in the western Pacific and is expected to remain moderately strong as it moves across the Pacific basin, then decrease in strength as it approaches Africa.

Climate change is also influencing the Australian climate. Australia's climate has warmed by around 1.4 °C since 1910, while southern Australia has seen a 10–20% reduction in cool season (April–October) rainfall in recent decades.

Northern Australia likely to be wetter than average in coming months

The latest outlooks indicate an increased chance of above-average rainfall across most of Northern Australia during November 2020 – February 2021.

Wet season rainfall for the 7-month period of the northern wet season (October to April) is typically greater than average during La Niña.

Some parts of northwest Northern Territory and the central coast of Queensland experienced their northern rainfall onset over the last week.

Madden–Julian Oscillation to move into the western Pacific Ocean

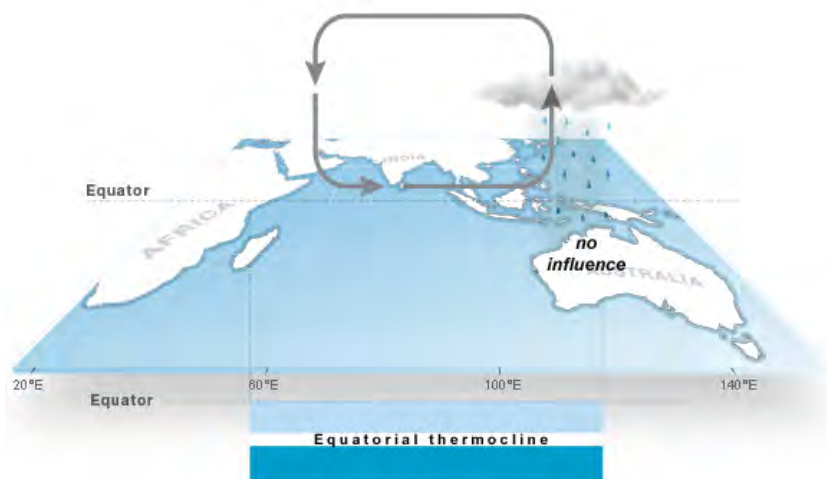
A strong pulse of the Madden–Julian Oscillation (MJO) is currently over the eastern edge of the Maritime Continent and is expected to maintain its strength and move into the western Pacific Ocean over the coming days, bringing increased westerly flow and rainfall to Northern Australia.

Indian Ocean Dipole

Sustained changes in the difference between sea surface temperatures of the tropical western and eastern Indian Ocean are known as the Indian Ocean Dipole or IOD. The IOD is one of the key drivers of Australia's climate and can have a significant impact on agriculture. This is because events generally coincide with the winter crop growing season. The IOD has three phases: neutral, positive and negative. Events usually start around May or June, peak between August and October and then rapidly decay when the monsoon arrives in the southern hemisphere around the end of spring.

Neutral IOD phase

Water from the Pacific flows between the islands of Indonesia, keeping seas to Australia's northwest warm. Air rises above this area and falls over the western half of the Indian Ocean basin, blowing westerly winds along the equator.



Indian Ocean Dipole (IOD): **Neutral phase**

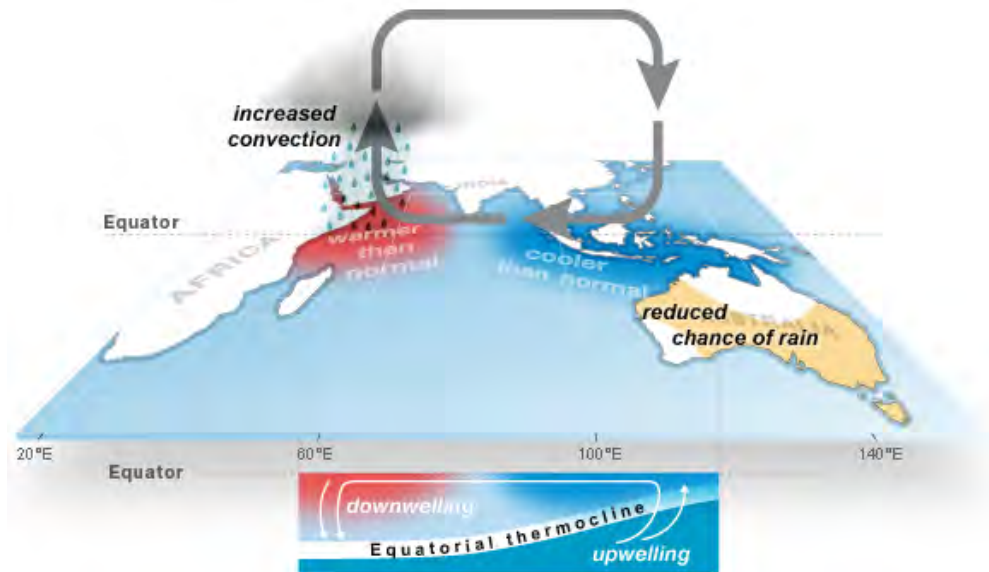
© Commonwealth of Australia 2013.

Temperatures are close to normal across the tropical Indian Ocean, and hence the neutral IOD results in little change to Australia's climate.

Positive IOD phase

Westerly winds weaken along the equator allowing warm water to shift towards Africa. Changes in the winds also allow cool water to rise up from the deep ocean in the east. This sets up a temperature difference across the tropical Indian Ocean with cooler than normal water in the east and warmer than normal water in the west.

Generally this means there is less moisture than normal in the atmosphere to the northwest of Australia. This changes the path of weather systems coming from Australia's west, often resulting in less rainfall and higher than normal temperatures over parts of Australia during winter and spring.



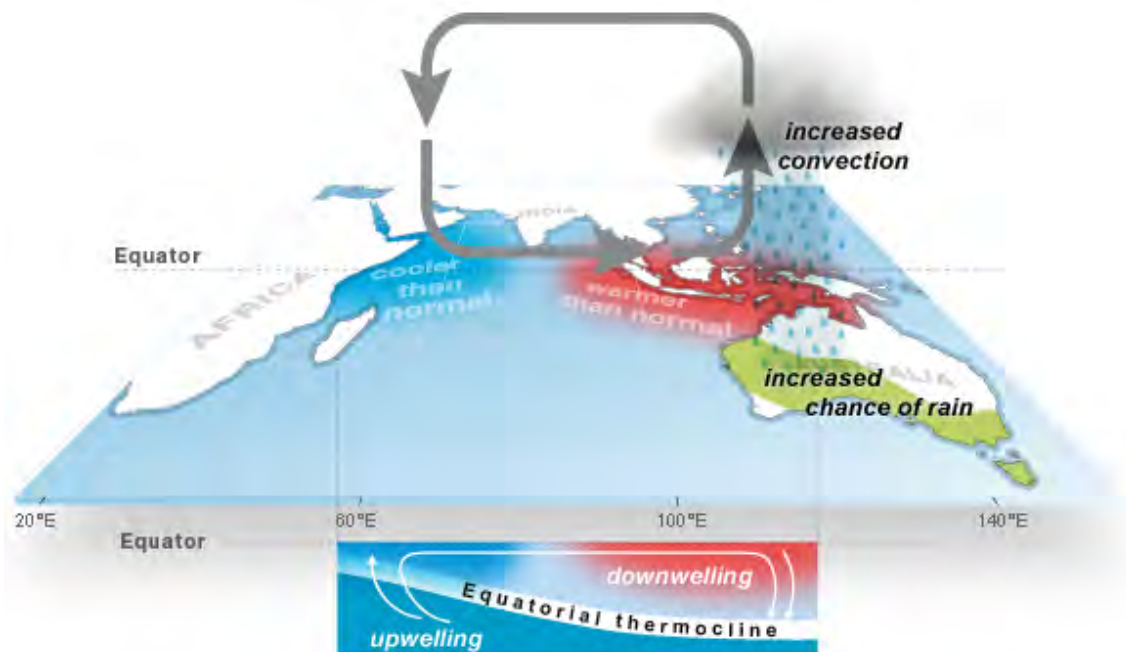
Indian Ocean Dipole (IOD): **Positive phase**

© Commonwealth of Australia 2013.

Negative IOD phase

Westerly winds intensify along the equator, allowing warmer waters to concentrate near Australia. This sets up a temperature difference across the tropical Indian Ocean, with warmer than normal water in the east and cooler than normal water in the west.

A negative IOD typically results in above-average winter–spring rainfall over parts of southern Australia as the warmer waters off northwest Australia provide more available moisture to weather systems crossing the country.



Indian Ocean Dipole (IOD): **Negative phase**

© Commonwealth of Australia 2013.

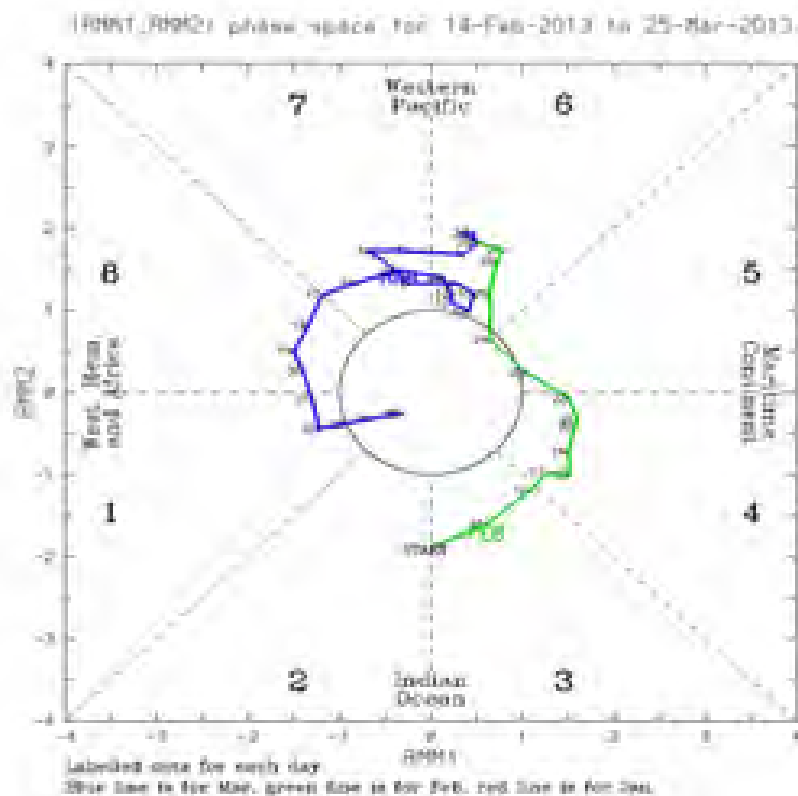
Video Understanding the Indian Ocean Dipole

<https://www.youtube.com/watch?v=J6hOVatamYs>



Madden-Julian Oscillation - BOM

Madden-Julian Oscillation (MJO) is the major fluctuation in tropical weather on weekly to monthly timescales. The MJO can be characterized as an eastward moving "pulse" of cloud and rainfall near the equator that typically recurs every 30 to 60 days. The MJO phase diagram illustrates the progression of the MJO through different phases, which generally coincide with locations along the equator around the globe. RMM1 and RMM2 are mathematical methods that combine cloud amount and winds at upper and lower levels of the atmosphere to provide a measure of the strength and location of the MJO. When the index is within the centre circle the MJO is considered weak, meaning it is difficult to discern using the RMM methods. Outside of this circle the index is stronger and will usually move in an anti-clockwise direction as the MJO moves from west to east. For convenience, we define 8 different MJO phases in this diagram. The numbered sectors in the box diagrams correspond to the number areas in the world ocean diagram and show the progression of the MJO around the world.



MJO – Weather Phases

- Eastward progression of high convection area across ITCZ – high rainfall, thunderstorms
- Tracked by splitting into 8 phases, or areas



The BOM video is recommended:

Understanding the Madden–Julian Oscillation (MJO)

https://www.youtube.com/watch?v=UsWHHE_jkGE.



The Madden-Julian Oscillation is associated with weekly to monthly periods of enhanced and suppressed rainfall over parts of Australia.

This climate influence is related to: [The Australian Monsoon](#) [Tropical Cyclones](#) [Tropical Depressions](#)

The Madden-Julian Oscillation (MJO) is a global-scale feature of the tropical atmosphere.

The MJO is the major fluctuation in tropical weather on weekly to monthly timescales. The MJO can be characterized as an eastward moving "pulse" of cloud and rainfall near the equator that typically recurs every 30 to 60 days. However, the signal of the MJO in the tropical atmosphere is not always present.

MJO effects are most evident over the Indian Ocean and western equatorial Pacific. It influences the timing, development and strength of the major global monsoon patterns, including the Indian and Australian monsoons.

Tropical cyclones

Are also more likely to develop in association with certain phases of a strong MJO event.

The MJO is associated with variations in wind, cloudiness, and rainfall. Most tropical rainfall comes from tall thunderstorms which have very cold tops. Thunderstorms that have cold tops emit only low levels of longwave radiation. Therefore, the MJO can be monitored by using satellite measurements of outgoing longwave radiation (OLR) to identify areas of cloudiness (low OLR) within the tropics.

The MJO has its greatest effect on the tropical areas of Australia during summer. It may have some effect on parts of southern Australia, however this impact appears small when compared to the effect on northern regions, and remains the subject of research.

The MJO can have an effect on the timing and intensity of "active" monsoon periods in northern Australia. This can lead to enhanced rainfall - in both the intensity of the rainfall and the duration of the rainfall. The following provide further information on the MJO:

- The Weekly Tropical Climate Note provides information on the current phase of the MJO.
- Technical information and maps relating to the Real-time Multivariate MJO Index, which is a way of monitoring the climate and weather variations caused by the MJO. Please note that this product is a research product, and as such is not always updated and may be under-going continual changes as it is developed.

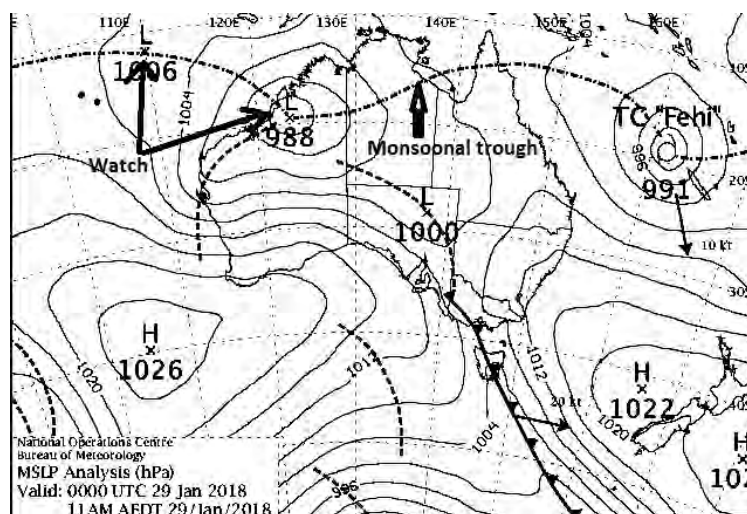
Cyclone seasons

Cyclones off northern Australia typically develop between 5 and 15°S and reach maximum intensity between 10 and 20°S. As they move further south they will weaken over land or, for those remaining over water, weaken as they encounter an unfavourable environment (strengthening wind shear) and move over cooler water. They usually increase in speed as the steering winds in the mid-levels of the atmosphere increase and move to the south or southeast.

Occasionally a cyclone moves south and interacts with a mid-latitude trough and undergoes extra-tropical transition changing from a warm-cored tropical low to a cold-cored mid-latitude low. The structure, distribution of winds and rainfall changes significantly. (Cyclone ITA April 2014)

Whilst the basics of cyclone development and behavior have not changed, the science and modeling available to met bureaus has. They have much more long-range tools available and a brief mention of some is useful. BOM Australia has dedicated website use instruction and sections. An example follows later in this article. If you are in the cyclone prone area November to April and away from internet services, there are radio and w/fx options.

Long range-, La Niña years have been correlated with an increased chance of wetter springs and higher numbers of tropical cyclones during the cyclone season (November to April). Also ENSO & MJO reports from the Bureau of Meteorology in their Tropical climate outlook. More later explains.



Medium range- Keep a watch on the monsoonal trough and especially any lows that form on it.

Short range-Radio & fx warnings, visual signs of cloud and swell. Swell waves travel

relatively fast and usually in this situation described as 'oily, uncomfortable'.

Cirrus cloud appears and tails point to location.

The diurnal rise and fall of the barometer ceases. Normally near the equator, the barometer will have a low at 4am and at 4pm with a high at 10am and 10pm. If the barometer has not risen at 10am it means a 4mb drop! The diurnal change can be up to 4 mb near the equator but more likely towards 3 mb in danger areas. In Melbourne it is 1.2 mb (This is atmospheric tide, usually peaks 0400 & 1600)

Use Buys Ballots law to determine the direction of the centre. *In the Southern hemisphere stand facing the wind and the low will be at your outstretched left hand or slightly further back.*

If the wind is steady in direction, you are directly in the path of the system.

If the wind backs, (moves anti-clockwise), the system will pass to your left meaning you are in the dangerous quadrant of the non-navigable semicircle.

If the wind veers, (moves clockwise), you are in the navigable semi-circle and the system will pass on your right.

Make sure some authority knows your intentions.

Usually, if the system is moving S or SW, it will at some time curve towards the East and travel faster.

In your contingency plans for the area should be at least a broadscale chart with suitable anchorages marked. Always remembering that storm surge can increase sea levels 3-6m above high tide and well above fringing reef. An ideal anchorage is protected from all quarters with a 'soft' shore of hopefully mud and mangroves.

How do you prepare for a cyclone?

Preparation is the key to surviving these storms. Any mariner visiting or living in the state should be aware what preparations are necessary when cyclone season arrives.

There have been a few complaints about lack of preparedness by yacht owners and the need for cyclone contingency plans by marinas, but these plans already exist.

Queensland's Department of Transport and Main Roads has comprehensive 'Extreme weather event contingency plans' (EWECP) available for every port that can be downloaded from the website (www.msq.qld.gov.au). As plans may differ from port to port, mariners should acquaint themselves with the plan for the port where they will be staying during cyclone season. Even experienced mariners should re-acquaint themselves with the requirements regularly.

Marinas also have contingency plans: non-cyclone rated marinas will evacuate; cyclone-rated marinas have different cyclone contingency plans which dictate what actions boat owners/operators must take to prepare for the coming severe weather event while sheltering in the marina. As requirements may change from marina to marina boat owners should discuss such issues with marina management prior to a weather event.

In Cairns for instance, any marinas that are not cyclone rated must be evacuated with boats seeking safety in the protective mangrove creeks of Trinity Inlet.

Cyclone contingency plans have been available from the Regional Harbour Master in Cairns and also available from the marinas. They show a map of the area and advise mariners where the various designated anchorages are located. Occasionally I have noticed boats being left in Cairns Harbour during cyclones but MSQ states that anyone leaving their vessel in the port area may be liable to prosecution and also be held accountable for any damage their vessel may cause or incur to other infrastructure.

Insurance companies also have very strict requirements and these may differ from company to company, so boat owners should familiarise themselves with their policy and be aware of what is covered and what is not. Contact your insurance company and talk to them.

Too many people think that once they are insured they have no more responsibility but it is not good enough to say, "I'm insured so it doesn't matter what I do." I have lost count of the number of times I have heard similar comments when a boat's been about to hit us. It definitely does matter to the person whose boat is about to be damaged.

Note also, the 'at fault' vessel owner may have difficulties with his insurer if he/she has not taken all precautions to prevent an incident.

Many complaints arise because the customer expects the companies to pay for absolutely everything whether the boat owner took responsibility or not. The insured cannot simply wipe their hands of any responsibility once they have paid their premium. They have an obligation to do everything in their power to ensure the safety of their vessel. In the opinion of the insurance reps I spoke to, removing sails, covers, awnings etc. is mandatory.

Insurance companies are not as concerned about the destroyed sail as they are about the nearby boats that have been damaged, even destroyed, just because that headsail was not removed. In winds of 140 knots even multiple lashings of rope will not hold up once the wind gets under a corner or the smallest opening.

What to do if unfortunately in the situation.

Most insurance companies agree preparations should be made when staying in a marina.

Lighten the boat: turn off all seacocks to toilets, sinks and to the engine but place a note in an obvious position noting the engine seacock is closed in case you need to start the engine. Remove all sails, boom covers, awnings, clears etc. and any loose items on deck and below. Secure all hatches and ports making sure they are sealed. Cupboard doors should be secured.

Tie any mooring lines to multiple cleats or other substantial tie-off points, not just one. Drop the anchor allowing lots of chain to go to the bottom: check with the marina that this is acceptable to them. Some may not agree with this.

The DMR state in its EWECP: "if it is not possible to remove sails, self-furling sails and covers, double wrap or tie these components in such a way that the wind cannot tease any ends out and allow flapping of gear to commence." However, my recommendation to those who are insured is to do everything in their power to follow the dictates of their insurance company.

The department's plan also states you should 'secure your tender. Ideally, tenders should be stored in dinghy lockers, garaged or deflated and stowed if applicable. If stored with the vessel, tenders should be securely lashed inverted on deck to prevent filling with water – do not contemplate towing tenders. If left on purpose-built davits, tenders should be cleaned out and securely lashed and bungs removed.'

Author's note: because we shelter in mangrove creeks our dinghy is stored on davits; it is emptied, the bow is raised as high as possible and the stern is left hanging low ensuring the engine is out of the water. The bung is removed but, as even a leaf is enough to block the bung hole, one side of the stern is positioned lower than the other so that accumulating

water can flow over one corner. Also, because we are on board, the outboard is left on the dinghy in case it has to be deployed suddenly in an emergency.

Mariners should read the DMRs comments in full, particularly with regard to marinas. In part it says “no guarantee can be given that the structures are capable of maintaining their integrity in the complete range of extreme weather conditions.

Remember vessels are moored at owners’ risk and it is the owner’s prerogative to move their vessel if they feel insecure in the marina.”

The department also recommends to double-up mooring lines, by running duplicated ropes to alternative bollards. Do not run duplicates to the same bollards. The duplicate lines should be in good condition and run slightly slack to ensure that they are only required to work in the event of the chafing through the primary mooring lines.

Take particular care to protect against chafing. Ensure lines are made fast to substantial boat parts, for example, mast steps, winches and so on, bearing in mind cleats are known to have been torn out of decks. Do not use chain to secure your boat to pontoon bollards. Chains have no ability to stretch.

If the master or owner elects to stay on-board, any mooring lines should be adjustable from on board and sufficiently taut to ensure the vessel and pontoon move as one.”

For vessels unable to access a cyclone-rated marina, preparations for tying in a creek will be slightly different: ensure your vessel is ready to move and you have heavy lines in good condition, the cockpit and decks should be clear and not cluttered. Have sufficient supplies to last at least several days and is your first aid kit fully stocked with plenty of required medications. Fuel supplies should be checked, batteries fully charged, VHF and commercial radios working.

When a warning is issued: double check supplies, lines, fuel etc.; keep an eye on the weather, noting each position of the cyclone as given by the Bureau of Meteorology and try to log its positions.

When it is time to head for your designated anchorage?

The authorities will keep all boaties updated on the status of the harbour via the VHF and by SMS if requested. When the yellow alert is issued head to your designated cyclone anchorage calmly and orderly. Common sense goes out the window if panic pays a call.

Enter your creek and find yourself a suitable spot to tie up. Choose a deep spot, preferably in a narrow creek with heavy mangroves on either side to which you can tie your lines. Go back as far as you can in the creek but you may find (particularly with multihulls) that when width no longer allows you to go further back there is still plenty of depth for monos. In that case, tie off to one side of the creek allowing enough room for monos to pass.

Once the creek is full, then tie off to the other side creating a web of lines and tie in securely. Drop your main anchor in the middle and, if you wish, reverse back until you can drop a stern anchor. Start running lines to the mangroves at 45 degrees from the fore and aft cleats or other strong points on both sides. If you have cleats amidship run lines from these also. The lines should be taken as low as possible to the largest and strongest part of the mangrove.

Recommend running additional lines from fore and aft cleats crossing over the boat to mangroves on the opposite sides of the creek i.e. lines from starboard cleats go to mangroves on the port side of the boat plus the reverse process. The boat has then been tied off in a web of lines which all return to the boat so that adjustments can be made as the tide rises and falls.

Many people tie to the mangroves but these lines cannot be adjusted easily and may be inaccessible when they need to be removed due to different tide heights. Chafing has never been an issue as the drama is usually over within a day and the lines can be adjusted to limit wear if necessary.

If you are in a wide section of creek, drop your anchors then rope the boat towards one bank securing as close as possible without running the risk of damage from broken mangroves. I must stress that only when all boats are in should you block the creek with your lines to the other side and they should be removed as soon as all danger has passed. You must not hinder the free movement of other vessels.

All soft awnings, clears, sails and boom covers are removed and all loose objects that could become a missile are stowed safely away.

If solar panels can not be removed, covering them to avoid damage from flying debris and lashing with rope may help protect them.

The wind will gradually strengthen and you will begin to surge on your lines. Check your lines for chafe and holding before the wind becomes too strong. Ensure they are not getting too tight. Remember tidal movement.

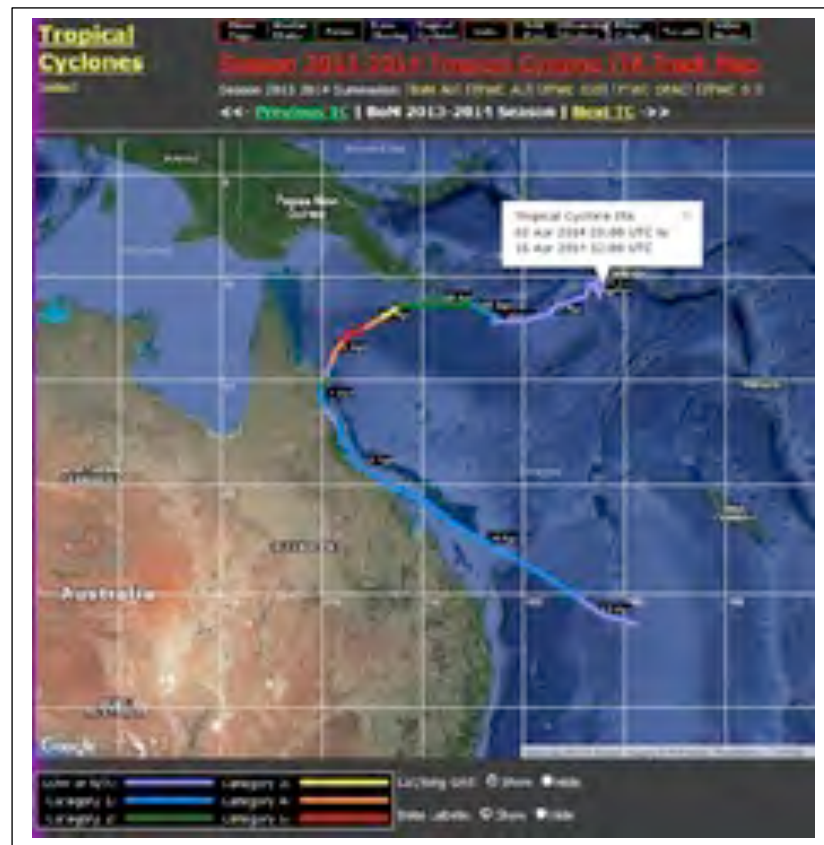
There will be plenty of rain so you can take this opportunity to fill your water tanks. If the cyclone hits at low tide you will find that you have a lot of protection from the mangroves. If the eye passes overhead there will be a period of calm. This is the time to take interesting photos as the boats are reflected perfectly in the glassy water. But whatever you do, do not untie your lines yet or move. Soon the wind will back and race in from the opposite direction. This is when most damage seems to occur. What has been loosened can be ripped away by the second onslaught.

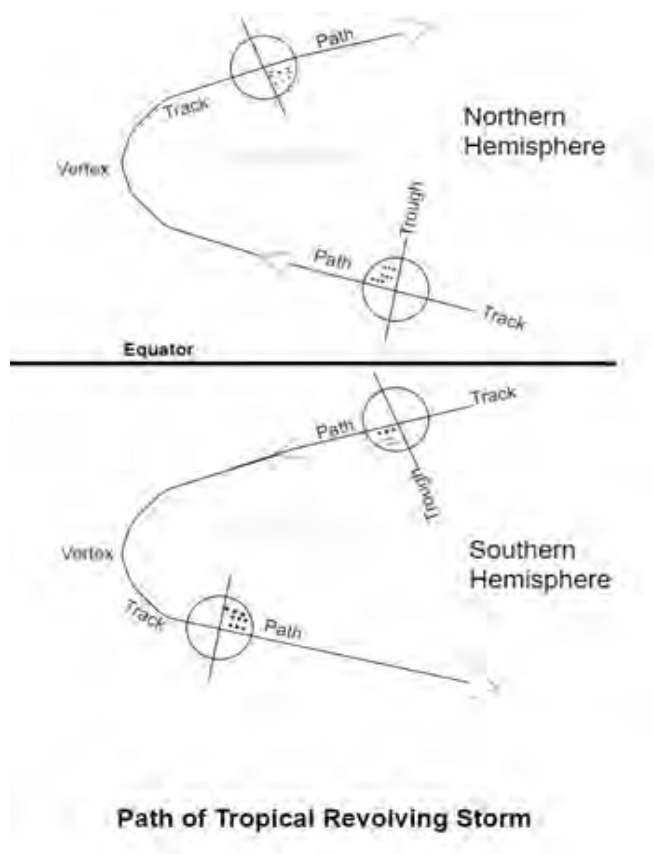
It is important to keep listening to the VHF as well as TV and commercial radio for updates.

Once the cyclone has passed over it will generally turn into a rain depression. Mariners should maintain a listening watch on VHF 16 and 12. There could be debris in the harbour in which case it will remain closed until the Harbour Master deems it safe for boats to return to their moorings and berths.

Under no circumstances must you leave your designated cyclone anchorage until permission is given, then head back slowly and sedately. You never know what will be in the water so proceed with care. If you decide to remain where you are for a while longer remove all unnecessary lines so that vessels behind you can move if required. Another very important thing to remember is that at all times during the cyclone including getting to and from your designated cyclone anchorage you are in control of and responsible for, your vessel. Despite regular practices of the past, this is not 'party time'.

Tracking and paths

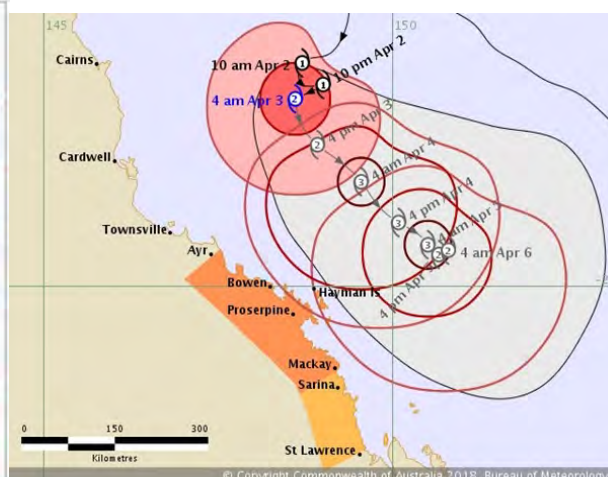




There is a 'standard' path behaviour, but tropical revolving storms are not creatures who follow the rules. The various met organisations have experienced people and all the technology at their disposal. They are able to predict a cyclones path in a probabilistic manner, however an often followed behaviour is to move westwards and slightly polewards before either crossing land or heading eastwards and polewards. At the track vertex is often where they are strongest. If they touch onto land and then turn out to sea, they intensify rapidly. If they cross onto land, their source of warm moisture and thus energy is diminished and they become a rain-bearing depression. If they continue polewards, they eventually encounter the associated winds of the sub-tropical ridge belt which 'cuts' off their vertical structure of a warm core. They may transition into an extra-tropical cyclone with a cool core and continue curving polewards and to the east-wards. In our mid-latitudes down the eastcoast and on to New Zealand.

Australian tropical cyclone intensity scale

Category	Sustained winds	Gusts
Five	>107 kt >198 km/h	>151 kt >280 km/h
Four	86–107 kt 158–198 km/h	122–151 kt 226–280 km/h
Three	64–85 kt 118–157 km/h	90–121 kt 167–225 km/h
Two	48–63 kt 89–117 km/h	68–89 kt 126–166 km/h
One	34–47 kt 63–88 km/h	49–67 kt 91–125 km/h



Action to avoid a tropical revolving storm. First principle is to get as far to the side as possible as the wind decreases the further out. Secondly aim to get behind it as it will roll over you if anywhere in front and prolong the danger. Track speeds are variable but averages are in the order of 10-12 kts. Do the maths. There are two sides to a cyclone one being the navigable side and the other non-navigable. Use Buys-Ballots law to determine which side you are on.

SH face the wind and low pressure (the centre) is approx. on your left

NH face the wind and low pressure is on your right.

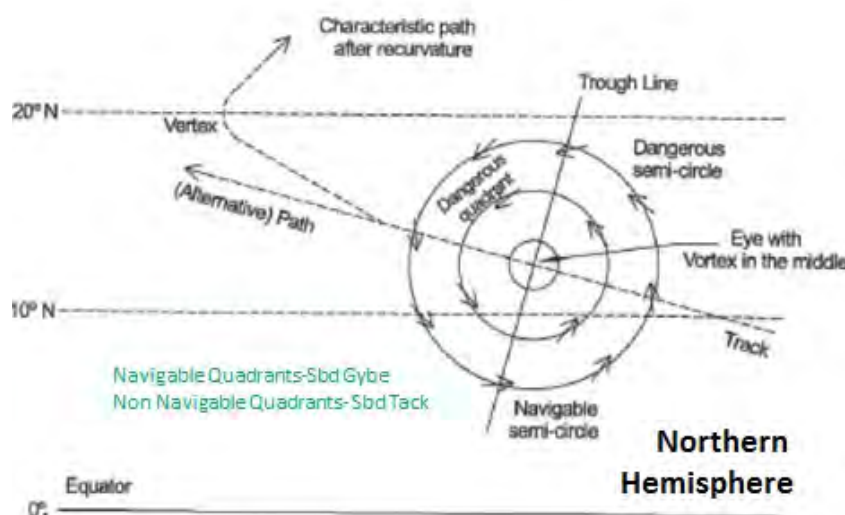
SH Non-navigable side –sail on port tack.

SH Navigable side-sail on port gybe.

NH Non-navigable side-sail sbd tack.

Navigable side-sail sbd gybe.

Action Required Southern Hemisphere



Monsoon seasons

A monsoon is not just any heavy rain that lasts for a long time. Rather, a monsoon is like a giant sea-breeze. A normal sea breeze changes daily, with the day-to-night change of land temperature as the sun rises and sets; monsoons change seasonally. Most of the time during the summer, the land is warmer than the ocean. This causes air to rise over the land and air to blow in from the ocean to fill the void left by the air that rose. Rising air leads to cloud formation and precipitation. These monsoon clouds that form are full of moisture from the ocean, so they can produce heavy rainfall for long periods of time. Because the land stays warmer than the ocean for most of the summer and the ocean is a constant source of moisture, these heavy rains last for months at a time. A monsoon climate is marked by dry winters and wet summers. About a quarter of the globe experiences a monsoon climate.

Asian-Australian monsoon – affects south-eastern Asia, the Australasian islands, and northern Australia. This monsoon happens from December to March because these areas are located slightly east of the opposite end of the Indian summer monsoon circulation. Since these areas are south of the equator, December through March is their summer, making this a summer monsoon, too.



Even if your weather isn't directly affected by a monsoon circulation, your climate is. Monsoons are very large-scale circulations that can simultaneously affect and be affected by global climate. For instance, if El Niño is weak, the Indian summer monsoon is heavier than normal. This could start a chain reaction throughout the atmosphere, causing stronger lows and heavier rain to form downstream, or toward the east. These chain reactions that affect weather patterns throughout the world are called global teleconnections.

Active Monsoon is characterized with deep westerly winds from at least the surface to 20,000ft with cooler temperatures and a moist troposphere. Thick sheet-like clouds in the mid and upper levels with embedded cell-like convective clouds producing squally showers and rain.

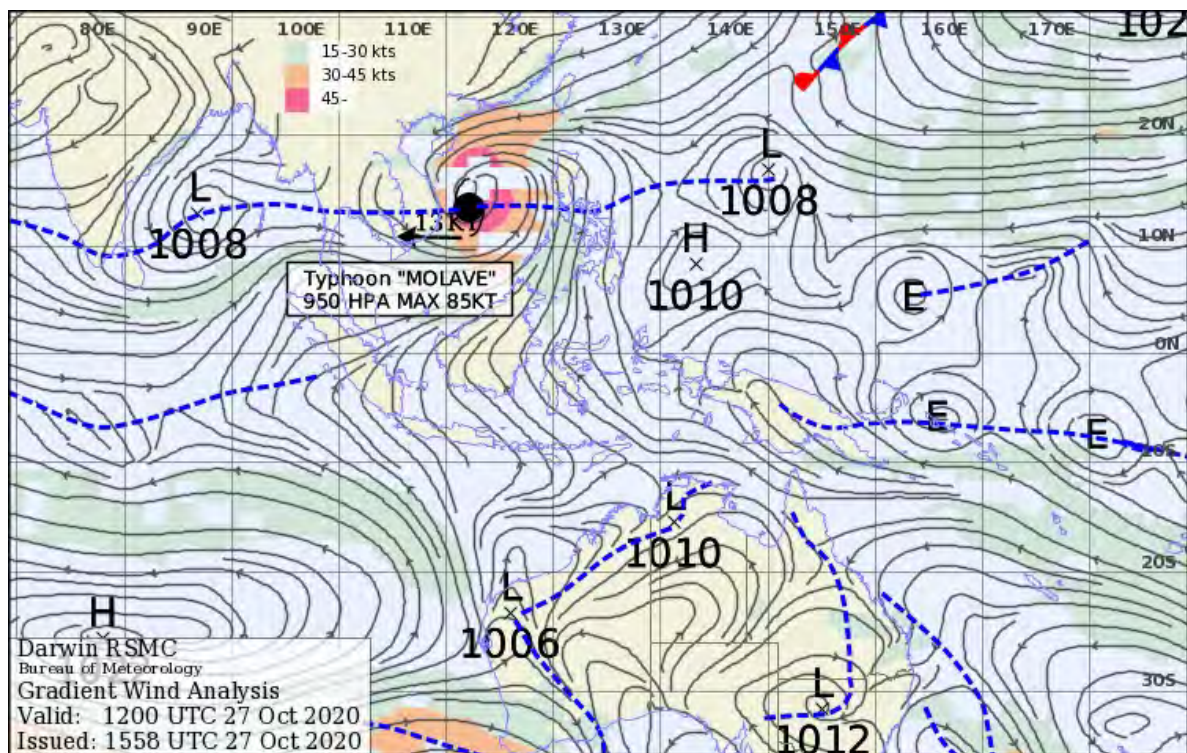
Break Monsoon (monsoon takes a break) has shallow westerly or easterly winds with warmer temperatures and 'dry slots' in the troposphere. Isolated thunderstorms made up of Cell-like cumulonimbus clouds which produce isolated regions of heavy rain. Meteorological science is still developing with a connection apparent with Himalayan ice under research.

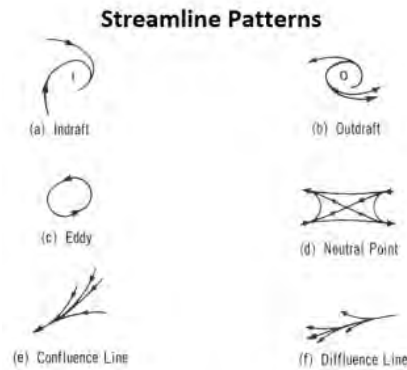
Sailing in the tropics

Gradient level Wind Analysis is best used for the tropics and especially so for the northern Australian coastlines where the very small pressure differences render conventional weather maps of little use. Adjustment is required to reduce wind strength for friction 20% over sea and 40% over land. Wind deflections for highs and lows also must be factored in for direction varying from 10% near the equator and more further away. Up to 30%. In SH looking along the direction of flow, deflection crossing the streamlines will be to the right. In the NH deflection across the stream lines when facing along the direction of flow will be to the left.

The Gradient Level Wind Analysis is a snapshot of the geostrophic airflow near the surface of the earth but above the friction layer. About 3,000 ft. It does not account for land effects, sea-breezes or downslope winds. The arrowed lines are called streamlines and represent the direction of the wind. The dashed lines are called isotachs, and connect points of equal wind speed. The standard isotach intervals are 15 and 30 knots (28 km/h and 56 km/h) - knots is the preferred unit for these charts as they complement the Bureau's marine services. Adjustment is required for windspeed friction loss at surface (20%) and deflection resulting-read above. Lows are marked with L, highs with H and E is for eddie.

Current Gradient Level Wind Analysis, twice daily, 00 UTC and 1200 UTC
Asian Region Gradient Level Wind

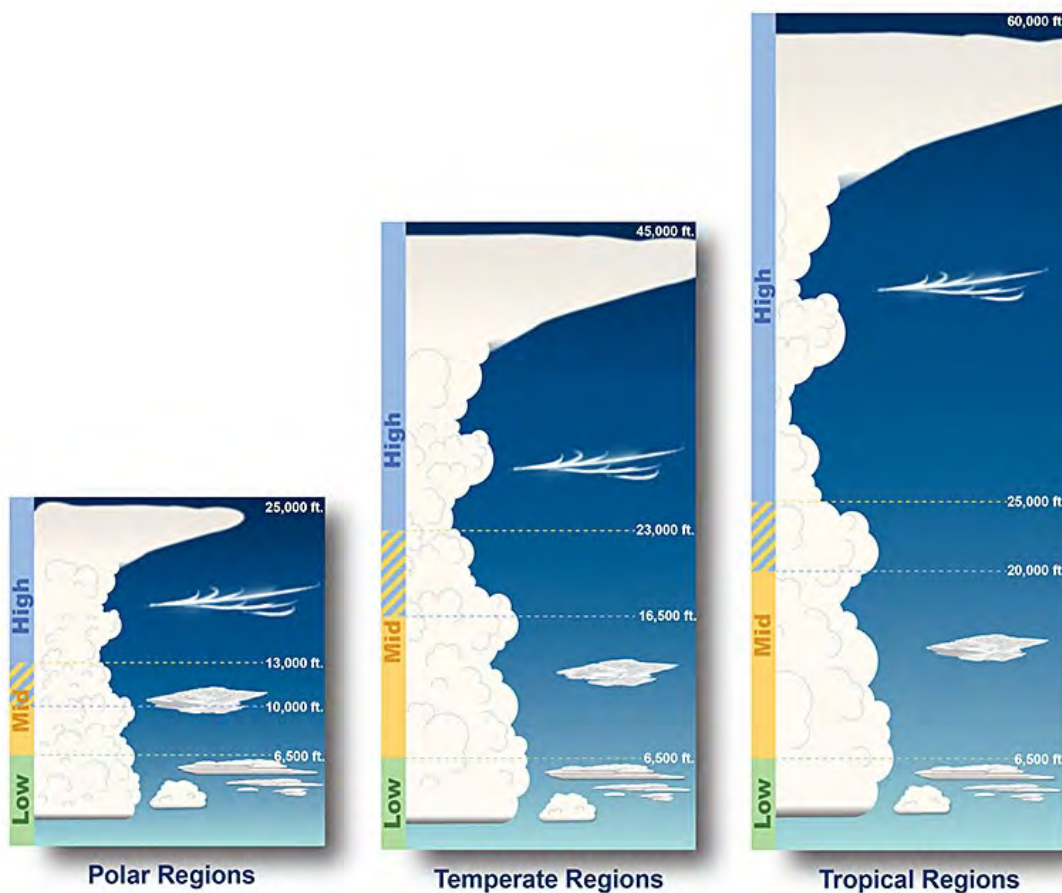




Black and white half domain charts are also available.

Asian Region Gradient Level Wind - Region A (Indian Ocean) west of roughly 123°E

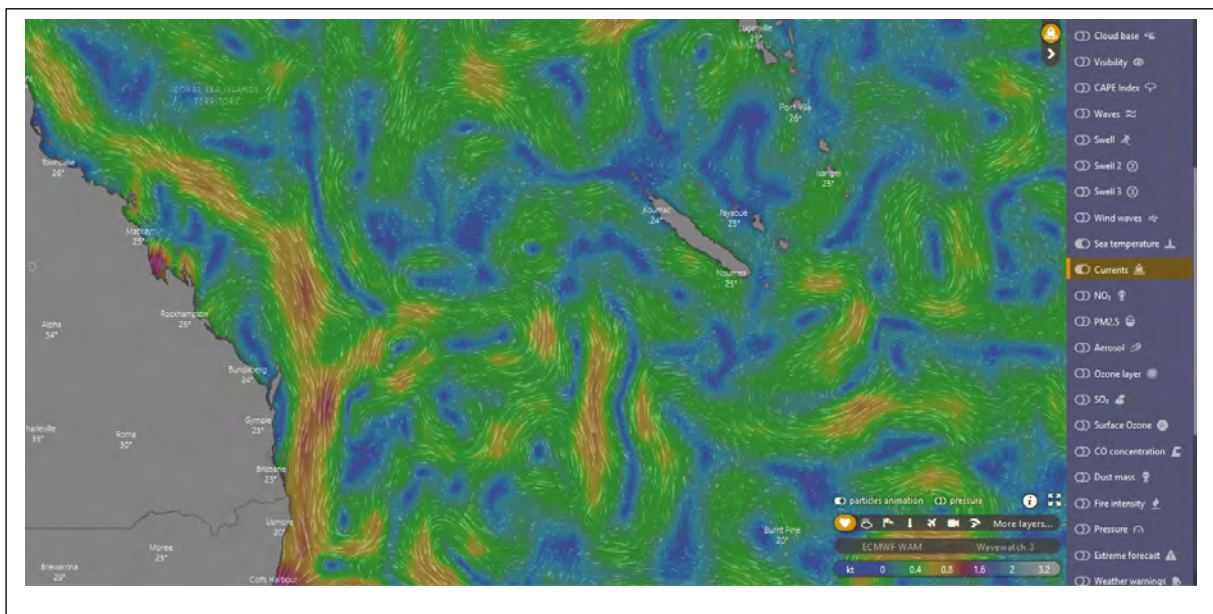
Another feature of the tropics is cloud height, due to the warmer conditions the atmosphere is considerably less dense and the troposphere reaches some 15 km high or 45,000+ ft approx.. Cloud structures fit within and condensation levels are therefore higher such that clouds are towering structures. Sea breezes are also a feature off islands and many islands are very steep razorback features eg. New Ireland. These islands have considerable influence on wind patterns and currents. Another surprise for mid-latitude sailors is the occurrence of warm fronts with cirrus clouds instead warning of light drizzle and winds.



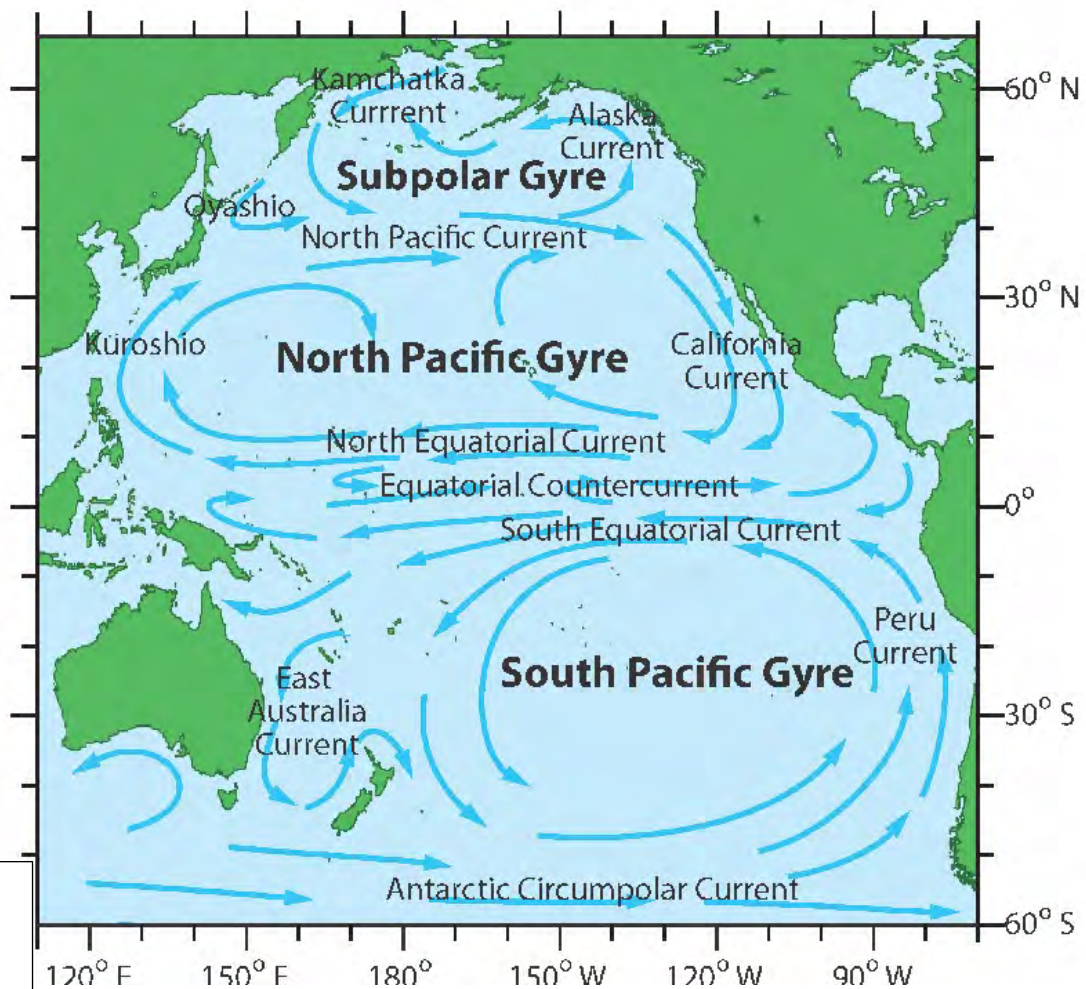
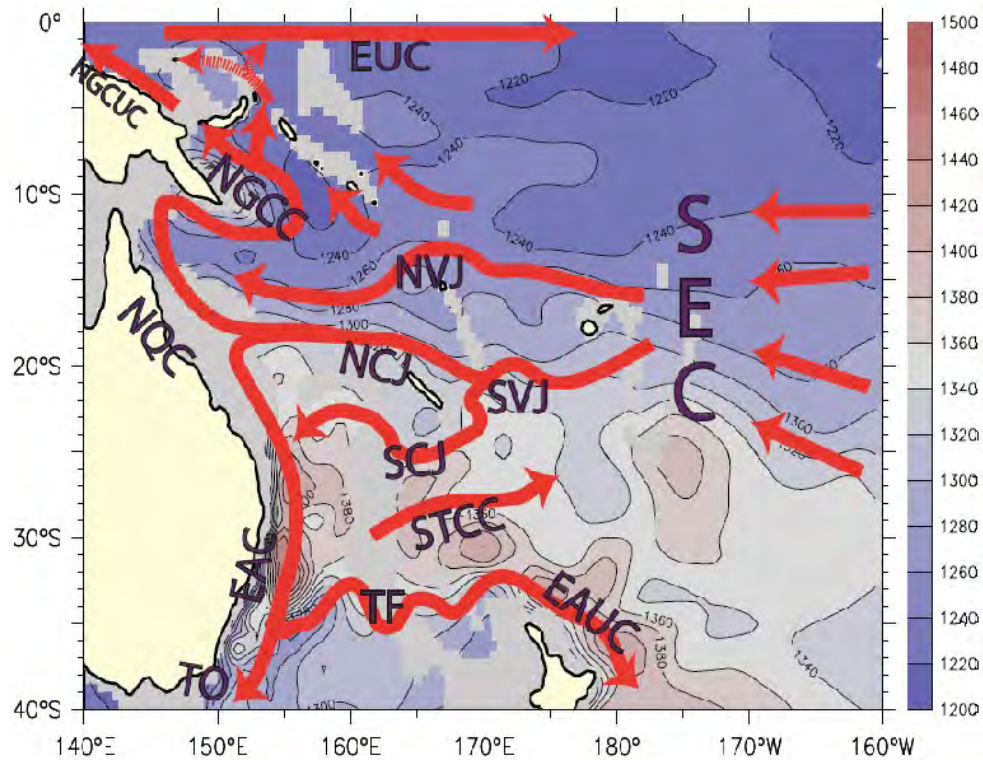
Currents

There are many undersea features in the oceans and their presence needs to be considered, obviously in terms of depth and influence on waves but more particularly on currents. One thinks of an ocean as a smooth vast expanse of deep water with little concern until land is neared. The reality is somewhat different. There are currents almost everywhere with eddies and current fronts. Especially when deep water currents encounter undersea irregularities, they can accelerate or be more one side than the other or be obstructed. The currents can be of a thermal nature or wind driven or tidal closer to land.

Ocean currents can also vary according to broadscale climate influences such as **El Nino** and **La Nina**. The undersea current circulations can also cause upwellings of cold water on an irregular basis which has an effect locally. Bathymetry can also give similar effects as in atmospheric situations with divergence, convergence, accelerations and jets. The main currents are well known and like all sciences, the development of new research is yielding constant new information. In this regard Windy.com with their currents selection is astounding but by its' nature is not clear if the displays are current or based on permanent flows but most likely are from satellite technology. To what degree they might be useful for longer term forward planning is yet to be ascertained.



SEC - South Equatorial Current	NVI - North Vanuatu Jet	SVI - South Vanuatu Jet
NCI - North Caledonia Jet	SCI - South Caledonia Jet	NQC - North Queensland Current
NGCC - New Guinea Coastal Current	NGUC - New Guinea Under Coastal Current	
EAC - East Australian Current	TF - Tasman Front	TO - Tasman Outflow
EUC - Equatorial Under Current (Through Solomon Straits)	EAUC - East Auckland Under Current	
STCC - Sub Tropical Counter Current	STF - Sub Tropical Front	
WE – Wairarapa Eddy	ECC – East Cape Current	



The Australian Bureau of Meteorology

The Bureau (BOM) is acknowledged for the videos referred to in this and other weather segments as well as the source of many diagrams and articles used or amended to more pointedly apply to marine recreational activity of our interests. There is considerably more information available within their website and routine reports are prepared on a weekly, fortnightly, monthly and annular basis.

Their libraries of videos and pamphlets on many subjects are extensive and familiarity with the layouts on side panels of any BOM web pages is advised before using their search box.

There are many other web sites of use and particularly NOAA from America has a very strong educational focus although of mainly Northern Hemisphere examples. For marine voyagers worldwide, the NOAA forecast regions are very extensive and whatever format one prefers is most likely available. Learning JUST where is another matter! And therefore when planning an international voyage, some familiarisation will be time well spent. Fortunately for Australians most weather broadcasters use English as well as their own national language.

Some BOM reports are available emailed via a subscription which is free. Specialised services are also available for a service fee if required for commercial activities.

Examples of the types of weather information available

Equatorial Rossby wave revives monsoon - BOM

Weekly Tropical Climate Note Issued on Tuesday 26 March 2013

An Equatorial Rossby (ER) wave, a westward-moving wave of tropical weather, is crossing Australian longitudes this week. The wave has contributed to a re-activation of the monsoon trough over the Australian tropics and northern seas. Numerical weather models predict the formation of a tropical low within the trough during this week, although the location and strength of the low remains uncertain. This development may lead to a short period of monsoon-like conditions about the 'Top End' of the Northern Territory and Kimberley region later this week, extending into the Easter long weekend. Above average rainfall and a slight increase in the risk of tropical cyclone development are forecast during this period.

The Madden-Julian oscillation (MJO) is currently in the African region, which favours below average rainfall for northern Australia (this week being the exception). The MJO is forecast to weaken and remain weak or indiscernible, having little impact on tropical Australian weather, until at least mid April.

See the Bureau's [MJO Monitoring](#) for more information on location and tracking of the MJO.

Tropical Pacific remains ENSO neutral

Atmospheric and oceanic indicators of the El Niño-Southern Oscillation (ENSO) continue within the neutral range. The 30 day Southern Oscillation Index (SOI) to 24 March is +8.0. The recent increase in the SOI has been due to persistent high pressure over the central Pacific Ocean, and is not considered indicative of the broadscale climate.

See the Bureau's [ENSO Wrap-Up](#) which includes a compilation of ENSO computer model predictions.

Tropical cyclones mark an increase in tropical weather - BOM

Weekly Tropical Climate Note Issued on Tuesday 8 April 2014

Tropical weather enhanced over the Pacific during the week. [Tropical cyclone Ita](#), currently located over the northern Coral Sea, caused loss of life and damage to property in the Solomon Islands last week and is slowly moving west and is expected to impact northern

Queensland later this week. In the northern hemisphere, tropical storm *Peipah* is tracking towards the Philippines.

Tropical activity is expected to increase to the north of Australia over the next seven to ten days. Tropical cyclone risk will be enhanced over the waters to the north of Australia during this time and Northern Queensland is expected to see an increase in tropical weather due to tropical cyclone *Ita*.

Predicted large scale tropical wave activity, including the Madden-Julian Oscillation (MJO), is the cause of the expected increase in tropical weather over the Maritime Continent region this week. The MJO is often associated with enhanced convection over northern Australia during this time of year. With Northern Queensland expecting tropical cyclone activity this week, and considering that April is late in the northern wet season, it is uncertain how much the influence of the MJO will be felt over the rest of northern Australia.

See the Bureau's [MJO Monitoring](#) for more information on location and tracking of the MJO.

Weekly Tropical Climate Note Issued 17 May 2016

The latest Weekly Tropical Climate Note is now available. Below is a summary of tropical weather and climate for the past week. Full details are available on our website.

Madden–Julian Oscillation persists in Indian Ocean

- The Madden–Julian Oscillation (MJO) remained at moderate strength as it moved eastwards across the Indian Ocean during the last week.
- Most models forecast the strength of the MJO to remain moderate as it moves into the Maritime Continent region.

Tropical activity increases over Indian Ocean

- Two tropical weather systems are currently being monitored over the Indian Ocean.
- The tropical low near southern India is in a favourable environment for possible tropical cyclone formation (more information here).

El Niño in its final stage

- Model outlooks and current observations indicate there is at least a 50% likelihood of La Niña developing in the second half of 2016 – about double the normal chance.
- La Niña is often, but not always, associated with above-average winter-spring rainfall over northern, central and eastern Australia.

The focus of convection migrates from the Australian/Indonesian region eastward towards the central tropical Pacific Ocean; and trade winds (easterlies) are weaker than normal.

This results in less atmospheric moisture available for rain in Australia. In the past, El Niño years have been correlated with an increased chance of drier springs and a reduction in rainfall over eastern and northern Australia.

Due to the complexity of land-ocean interactions across the Pacific, no two La Niña events, and no two El Niño events, are exactly the same. Similarly, the SOI cannot accurately predict rainfall for Australia on an event by event basis. Rather, indicators of the El Niño–Southern Oscillation serve as a guide to the chance (probability or likelihood) of receiving more or less rainfall in a given season.

- Seasonal outlooks are issued in October and may be updated during the season. They are removed at the end of the season.
- Three-day outlooks are issued during the cyclone season for most areas. They are issued throughout the year for the Central Indian Ocean area.

Rossby Waves (Mostly northern hemisphere dissertation).

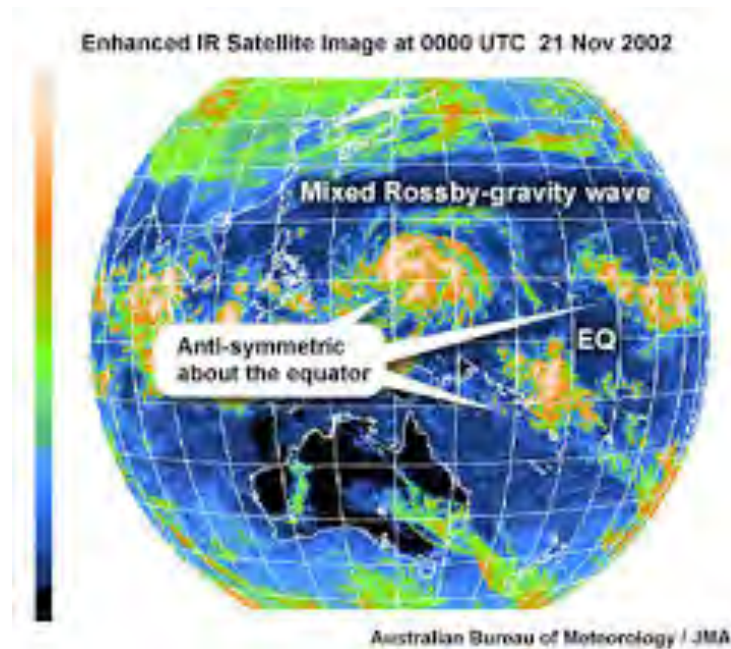
In meteorology, large horizontal atmospheric undulation that is associated with the polar-front jet stream and separates cold polar air from warm tropical air. These waves are named for Carl-Gustaf Arvid Rossby, who first identified them and explained their movement.

Rossby waves are formed when polar air moves toward the Equator while tropical air is moving poleward. Because of the temperature difference between the Equator and the poles due to differences in the amounts of solar radiation received, heat tends to flow from low to high latitudes; this is accomplished, in part, by these air movements.

Atmospheric Rossby waves emerge due to shear in rotating fluids, so that the Coriolis force changes along the sheared coordinate. In planetary atmospheres, they are due to the variation in the Coriolis effect with latitude. The waves were first identified in the Earth's atmosphere in 1939 by Carl-Gustaf Arvid Rossby who went on to explain their motion.

One can identify a terrestrial Rossby wave in that its phase velocity (that of the wave crests) always has a westward component. However, the wave's group velocity (associated with the energy flux) can be in any direction. In general, shorter waves have an eastward group velocity and long waves a westward group velocity.

The terms "barotropic" and "baroclinic" Rossby waves are used to distinguish their vertical structure. Barotropic Rossby waves do not vary in the vertical, and have the fastest propagation speeds. The baroclinic wave modes are slower, with speeds of only a few centimetres per second or less.

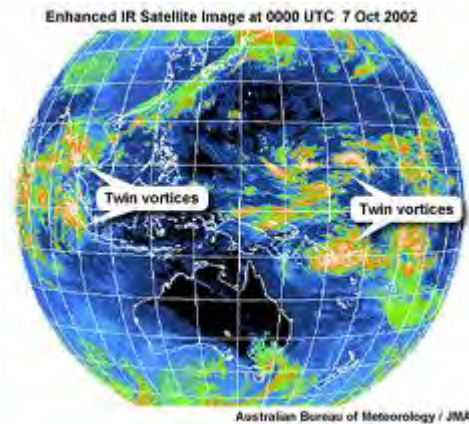


Most work on Rossby waves has been done on those in Earth's atmosphere. Rossby waves in the Earth's atmosphere are easy to observe as (usually 4-6) large-scale meanders of the jet stream. When these deviations become very pronounced, they detach the masses of cold, or warm, air that become cyclones and anticyclones (highs or lows) and are responsible for day-to-day weather patterns at mid-latitudes. Rossby waves may be partly responsible for the fact that eastern continental edges, such as the Northeast United States and Eastern Canada, are colder than Western Europe at the same latitudes.

Poleward-propagating atmospheric waves

Deep convection and heat transfer to the troposphere is enhanced over anomalously warm sea surface temperatures in the tropics, such as during, but by no means limited to, El Niño events. This tropical forcing generates atmospheric Rossby waves that propagate poleward and eastward and are subsequently refracted back from the pole to the tropics.

Poleward propagating Rossby waves explain many of the observed statistical teleconnections between low latitude and high latitude climate, as shown in the now classic study by Hoskins and Karoly (1981). Poleward propagating Rossby waves are an important and unambiguous part of the variability in the Northern Hemisphere, as expressed in the Pacific North America pattern. Similar mechanisms apply in the Southern Hemisphere and partly explain the strong variability in the Amundsen Sea region of Antarctica. In 2011, a *Nature Geoscience* study using general circulation models linked Pacific Rossby waves generated by increasing central tropical Pacific temperatures to warming of the Amundsen Sea region, leading to winter and spring continental warming of Ellsworth



Land and Marie Byrd Land in West Antarctica via an increase in advection.

Rossby Waves are atmospheric waves that are located in the mid latitude westerly winds with very long wavelengths that typically drift slowly eastward.

Cyclone formation

The energy source of a cyclone is latent heat. When water vapour turns to liquid and when liquid water turns to ice, heat is released. This provides the upward force to drive the system. An abundant source of vapour is found in the tropics where 26.5°C sea temperature is situated in extensive areas. A tropical low provides the initial uplift and if the upper atmosphere system allows the upward motion to continue uninterrupted, cyclogenesis occurs. Formation in the meteorological ITCZ of 5°N to 5°S latitude has insufficient spin from coriolis force to occur. Higher latitudes than 23° are unable to support uplift due to stronger winds which destroy the vertical requirement and rip the cloud off the top. Requires high sea temperature, high humidity, low wind shear to develop feedback process.

Communications

For the modern sailor, communications have advanced considerably and keeping in touch with family and friends has never been easier. Of particular benefit is the ability to download timely weather information from a worldwide array of providers, both Government and private. So much so that a balance is required to sail the boat and the amount of information one needs. There are routine weather tasks for daily update and perhaps more regular updates if in suspect areas. With all types of 'comms' systems, it takes some time to 'bed them in' as numerous hiccups occur. Marriage of radios, computers, fax systems and satellite equipment with power supply and connections has a history of difficulty which requires time to sort out rather than 'boffin' expertise. History proves also that having a working knowledge of the particular setup is of great benefit when at sea or away.

Familiarity with the weather products available from the appropriate agencies and their area of coverage is best practiced in advance via internet and thence tested on board. BOM products are extensive but there are many sites worldwide with different presentations. It takes some practice to discover what and where the products suitable to you can be found, many upper level maps can be found in Aviation sections. It is usually very difficult to discover required sources once underway.

Refer AWP-sigwx eg. Sail-mail pps refer Sailmail manual, JV Comm pps Demo memo
HF W/fax schedule pps Refer Reference material

Satellite communications

- Where: Global via satellite
- What: High seas warnings and forecasts, some coastal forecasts
- Schedule:
- Provider: Bureau for Australian high seas and coastal areas
- Details: Inmarsat C (SafetyNET)
-

As part of the Global Maritime Distress and Safety System (GMDSS) the Bureau transmits via Inmarsat SafetyNET marine weather warnings and forecasts. High seas forecasts and warnings are broadcast over the Pacific Ocean satellite, whilst the Western area is broadcast over the Indian Ocean satellite. Some coastal waters forecasts are broadcast via SafetyNET and currently include Northern Territory, Western Australia and Bass Strait forecasts.

HF voice radio & radiofax

- Where: Off-shore
- Details: HF marine radio weather services
- Provider: Bureau for weather. Other agencies for distress and safety services
- Voice
 - o What: Warnings and forecasts
 - o Schedules: Marine warnings are broadcast every hour, on the hour UTC. Forecasts and reports are broadcast on a fixed schedule repeated every four hours.
- Fax
 - o What: Warning summaries and charts
 - o Schedules
 - o How: Reception requires a marine fax unit attached to your HF radio or a personal computer connected through an HF modulator.

GRIB files

GRIB files are data files containing weather information, usually surface wind and surface pressure, on a (typically) 1 or 2 degree grid. The name comes from "**GR**Idded **B**inary or **G**eneral **R**egularly-distributed Information in **B**inary form". The GRIB files have ".grb" file extension.

The SailMail system can pass grib files, but only if they are less than 30kBytes in length if sent via Pactor-III or Pactor-4 (15kBytes via Pactor-II). Grib files need to have the ".grb" file extension. Out of sloth and laziness, some providers of grib files send files that are far too large (50kBytes or more). We have found that if you wisely pick your area coverage, time coverage, and spatial resolution, a 10 kByte grib file contains plenty of data to plan a trip, even crossing an ocean, and a 10kByte file is easily transferred over SailMail.

- NOAA's Global Forecast System (GFS) is widely regarded as the best worldwide computer weather forecast. US taxpayers pay to run the GFS and NOAA graciously makes the results free to everyone. The SailMail Association supports a system called SailDocs that formats Grib files containing NOAA GFS data for efficient transfer to mariners. The SailDocs system is available to everyone via any email system at no charge. This is sensible, given that the US taxpayers have already paid to run the GFS, so why should they be asked to pay yet again? For information on how to use SailDocs send an email to info@saildocs.com For specific information on the weather models and on how to get grib files sent to you via SailDocs, send an email to gribinfo@saildocs.com The AirMail software contains a handy tool to subscribe to grib files under that can be found on the main AirMail Message Index window under Window/Catalogs/Saildocs/Grib Files.
-
- There are various software packages that are used by computer-savvy cruisers and racers that display grib files of weather data. Some also display digital charts, and some can even calculate routes. The easiest grib viewer to use, and cheapest (free) is Jim Corenman's AirMail Weather Fax Companion that is available from the download page on this website and is included in recent downloads of the AirMail program. Other programs that can view grib files include Deckman for Windows, Expedition, MaxSea, Nobeltec, Oceans, and RayTech.

The science of weather is improving at a similar pace to all kinds of technology. The real challenge is now how to obtain the information. Satellite comms are increasing in use, but at this time are very slow and can be expensive. New systems and programs are constantly emerging to deliver lower resolution products enabling faster downloads and therefore a wider range of information. Therefore if planning a long duration offshore voyage much research and then practice with the system chosen is advised. 10 day forecasts are now readily available but some require subscription for longer than 7 days. Some are specifically tailored to select areas and the forecast models used should be considered.

Although the mostly used programs in Eastern Australia for offshore weather and routing come via Predictwind-Offshore, there are other programs available and emerging but these should be considered carefully as they may be specific for a particular area and not necessarily using the most applicable topographic and weather models for your desired voyage.

Some examples in the slides presented may seem of little relevance practically, but they are presented as background information to enable research or sufficient understanding to cope with terminology in information received or encountered. Otherwise much could be

considered 'too hard' whereas it merely advises it has been considered or used in arriving at a conclusion.

When following barometric readings for rise and fall, the large diurnal movements in the tropics can be puzzling to sailors from temperate regions. The changes in 'atmospheric tide' can be as much as 5 mb on the equator with a low at 0400 and 1600 and high at 1000 and 2200 daily. If sailing in tropical areas therefore, it is best to factor in the change to readings or better still to be consistent with reading times such that rises and falls are directly observable.

Saildocs is an email-based document-retrieval system for the delivery of text-based Internet documents either on request or by subscription. Saildocs can deliver web pages (including text weather forecasts, and provides subscriptions for automatic delivery. Additionally Saildocs provides custom grib weather-data files per request from data downloaded from NOAA/NCEP and other sources.

Saildocs offers text-based document retrieval and subscription services for offshore sailors, adventurers, missionaries and others who must somehow live their lives without fiber, DSL or even 56Kbaud dialup connections. There are currently two services offered, a document retrieval service which will return documents from the Internet or our own files, and a subscription service which will send Internet documents (for example weather reports) at scheduled intervals.

Saildocs is supported by the Sailmail Association (www.sailmail.com) and can be used by anyone who agrees to the terms and conditions (below).

For more information about Saildocs, send (a blank) email to info@saildocs.com For information on requesting grib weather-data files via email, send (a blank) email to gribinfo@saildocs.com. Available forecast and model info is available send (a blank) email to gribmodels@saildocs.com For information about our grib-viewer check their website.

The following is from Rod Smallman of 'Maverick' –competitor in the 2018 Melbourne-Osaka race.

A couple of points that I learnt from Osaka

I used Predictwind Offshore with IridiumGo and then brought the info into Expedition manually

The Satphone plan has unlimited data and sms ` about \$120US/month
Download speeds are not great with IridiumGo and I found 500kb to be the max practical file size

I could not get internet working properly with IridiumGo so I used saildocs to get any imagery that I wanted. This service is awesome and the reply is typically less than a minute. I used the Xgate software for emails as its compression stuff is great. Usually the saildocs return would be within the same send/receive action. Ie by the time Xgate had done its sending the saildocs reply was already available for download

Email query@saildocs.com

subject line: anything

body: send {URL} – eg send

http://www.data.jma.go.jp/mscweb/data/himawari/img/pia/pia_b03_0130.jpg

I broke my weather into 2 sections

Short term – 3 days

- Twice daily downloads
 - o EC HiRes(9km) model c/w pressure (6 hour interpolation for 3days)– about 600nm square ~ 500kb
 - o Current (1day – 60kb; 7 days 350kb) – for particular areas such as Kuroshio, Equator or EA currents
 - Hycom current GRIBS (from the GFS modelling) – is my preference
 - o Gradient Level Wind – downloaded via saildocs
<http://reg.bom.gov.au/fwo/IDD67950.png> - this is the 00zulu, the 12zulu ends in 60.png
- In the ITCZ I swapped from downloading GRIBS to the following but still downloaded the longterm GFS GRIB
 - o Satellite Images
 - http://www.data.jma.go.jp/mscweb/data/himawari/img/pia/pia_b03_0130.jpg
 - I couldn't find a generic link for these so I just took off 20mins off the UTC time for the image name to get the near realtime sat image
 - o ASCAT images
 - <https://manati.star.nesdis.noaa.gov/datasets/ASCATData.php/ASCATData.php>
 - https://manati.star.nesdis.noaa.gov/ascat_images/cur_25km_META/zooms/WMBas272.png

Long Term – 14 days

- Daily or every second day – depending up how stable the gribs were from day to day.
 - o GFS 100km model c/w pressure (12 hour interpolation for 14 days(maximum on predictwind)) – about 300nm square ~ 200kb
- This kept my downloads to a minimum
- I always had the latest HiRes(9km) for 3 days out
- For the longer term the LowRes(100km) were more than sufficient for bigger picture – especially with pressure added
- I downloaded the ASCAT images daily to confirm accuracy of GRIBS

- ASCAT & Satellite images were my best friends for finding wind in the ITCZ
- Saildocs awesome for satphone imagery
- My preference is for EC modelling over GFS
- In general I found the actual wind to be about 10-20% more than the GRIB wind. I put this down to my windex being at 16m height rather than the 10mGRIBS
- I used the pressure on the GRIB in comparison with actual pressure to verify the positional accuracy of the GRIBS

ASCAT - Advanced Scatterometer

Not too many people know about ASCAT image but they are near real time actual wind strength and direction (see below for description)

The Advanced Scatterometer (ASCAT) winds products are processed by NOAA/NESDIS utilizing measurements from the scatterometer instrument aboard the [EUMETSAT](#) Metop satellites. The instrument uses radar to measure backscatter to determine speed and direction of winds over the surface of the oceans. ASCAT data feeds numerical weather prediction models, provides useful information on ice, snow and soil moisture, and is used to analyze areas of individual storm activity.

The following images are available:

Surface Winds Images

Surface winds images are created hourly for ascending and descending 25 km and 50 km data. Daily images are archived for 7 days. The following link provides wind product monitoring information in near-real time: [OSI SAF ASCAT-A 25-km monitoring](#)

BOM Weatherfax and Schedules - visit

[VMC & VMW Radio Fax Schedule - Bureau of Meteorology](#)

[www.bom.gov.au](#) › Marine & Ocean › Communication Services

Jul 1, 2017 - Frequencies and technical details: VMC (Charleville) - VMW (Wiluna) ... VMC/VMW Schedule - 2 pages. ... Recommended Frequencies for VMC (Charleville) - 3 pages.

[HF Marine Radio Services - Bureau of Meteorology](#)

[www.bom.gov.au](#) › Marine & Ocean › Communication Services

VMC Fax frequencies (kHz);, Fax schedule. Fax broadcasts run on a 24 hour cycle. [www.bom.gov.au/marine](#) or by faxing 1902 93 5046 (call costs \$1.38 per ...

[Worldwide Marine Radiofacsimile Broadcast Schedules](#)

[www.nws.noaa.gov/os/marine/rfax.pdf](#)

Sep 21, 2017 - frequency and scheduling information as well as links to products. A listing of other recommended webpages may be found in the Appendix.

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