Weather, Current and Routing Brief

The Clipper 11/12 Round the World Race

Prepared for the Race Skippers

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27th April 2011

This has been prepared using publicly available free access sources of weather, climate and current data, and all the sources are cited.

1. Leg One - Europe to Rio de Janeiro (early August to mid September)

1.1. The Route

The route shown (*Figure 1.1.1)* is in two main legs – Europe to the Inter-Tropical Convergence Zone (the ITCZ), and the ITCZ to Cabo Frio. The nominal position for the ITCZ crossing is shown as the Equator at about 29^{O}W, but this depends on the conditions at the time.

Fig 1.1.1: overall route from the Iberian Peninsula to Rio de Janeiro, showing the two main legs (1)

The great circle route also goes straight through the Canary Islands (*Figure 1.1.2)* which are a significant early navigational dilemma.

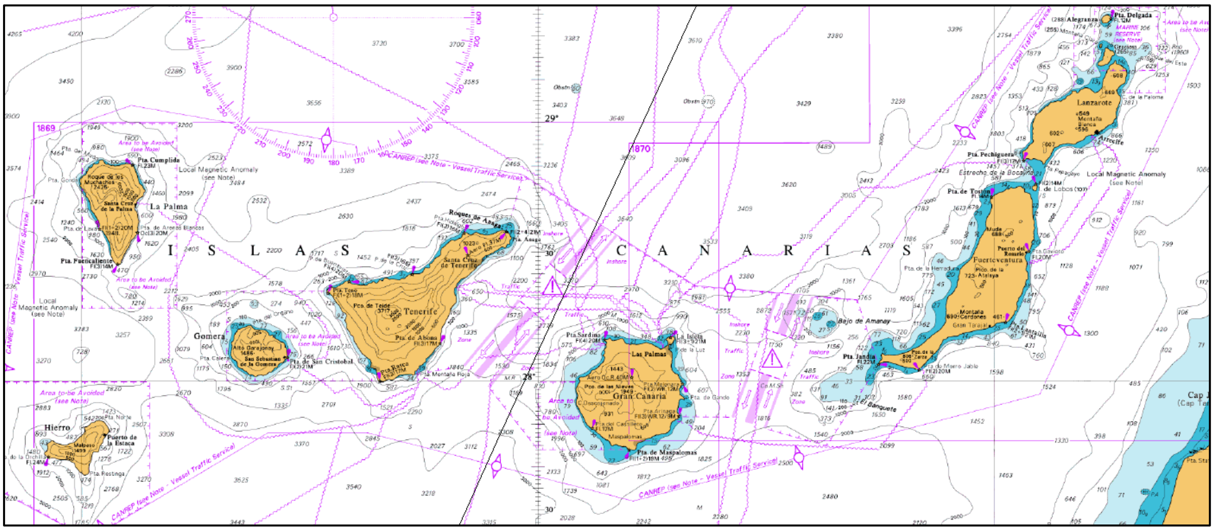


Fig 1.1.2: Islas Canarias (2)

Once across the equator the route has a large section of virtually coastal navigation from the Abrolhos Bank (18^{O}S, 38^{O}W) to Cabo Frio (23^{O}S, 42^{O}W). There are many (thankfully well charted) hazards in this section (*Figure 1.1.3).*

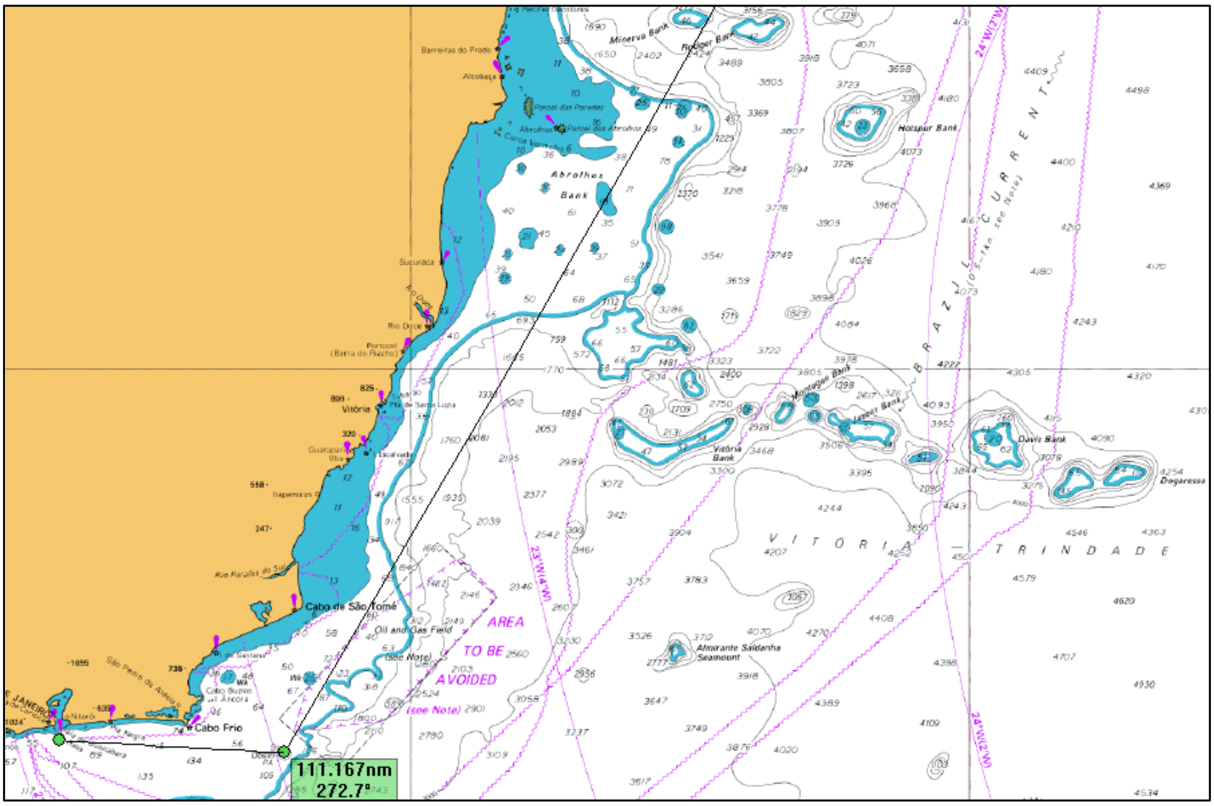


Fig 1.1.3: the Abrolhos bank to Cabo Frio (3)

1.2. The Weather

This is possible the most complex leg, as the route goes from mid-latitudes in the northern hemisphere through the sub-tropical zone, the tropics, the ITCZ, then the whole lot again in reverse with everything rotating the other way in the southern hemisphere. This is why it is important to do the preparation beforehand and then keep a very close eye on conditions and forecasts as you go. This will start at the Iberian Peninsula, as anything north of that will be familiar territory anyway.

1.2.1. The Iberian Peninsula to the Canaries

The routing chart for August (*Figure 1.2.1.1)* shows 80% plus winds from either N or NE, generally around force 4. This would be a wonderful thing if it were always so. As ever the routing chart shows a historical average, and the reality is often different.

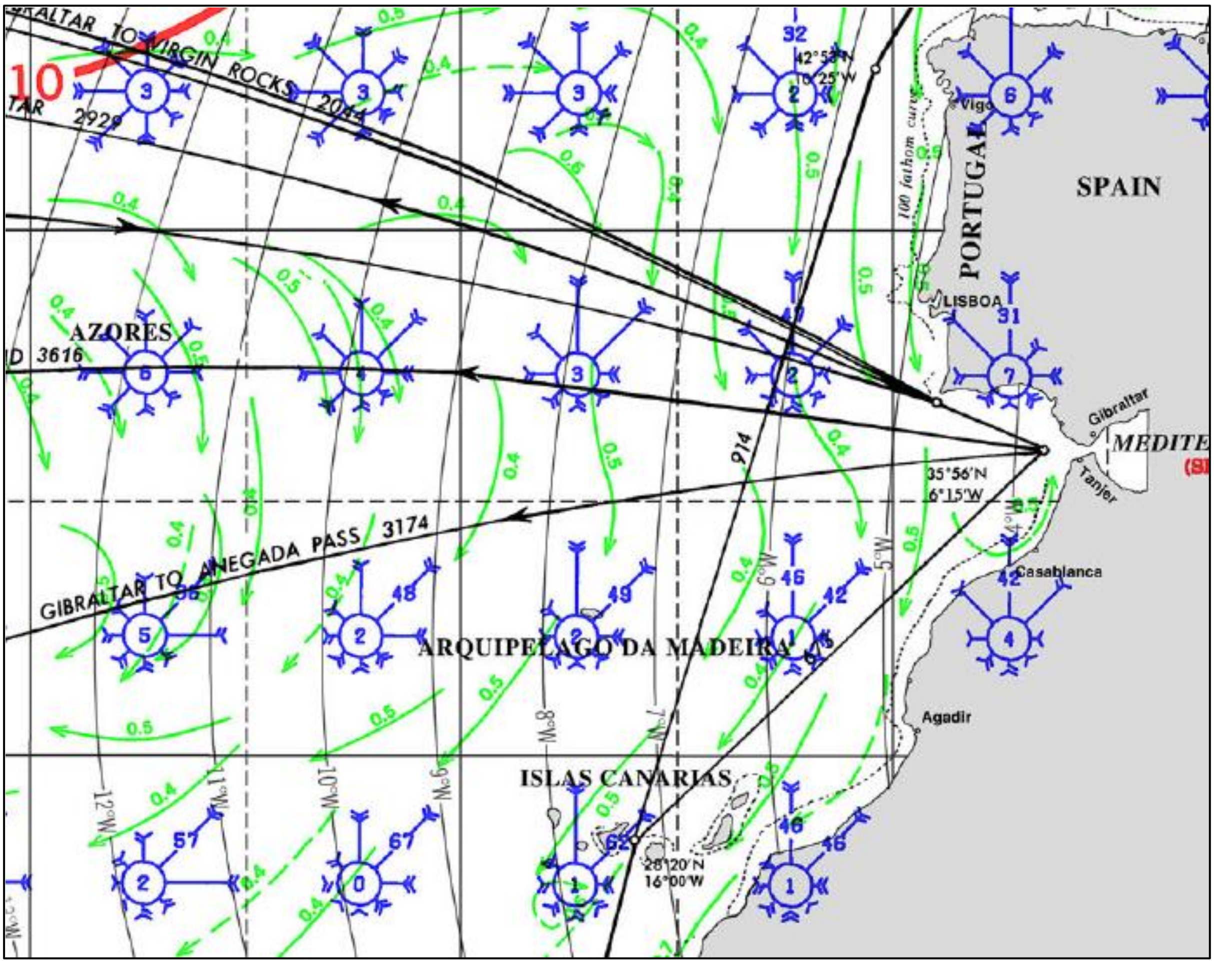


Fig 1.2.1.1: section of the North Atlantic Routing Chart for August (4)

This section marks the transition from the depression-driven mid-latitude weather to the north and the anticyclone-driven weather of the Tropics to the south. This transition zone sees both these options and more, therefore. The one that makes life much easier is shown (*Figure 1.2.1.2)* with the North Atlantic High (NAH) firmly in place over the Azores, its “standard” position, NE Trades going across the Atlantic and a tropical depression moving north of the Caribbean chain. This gives N winds coming down from the Iberian Peninsula. Remember to multiply m/s by two to get knots, and note that the isobars have a 2 hPa spacing to show more detail.

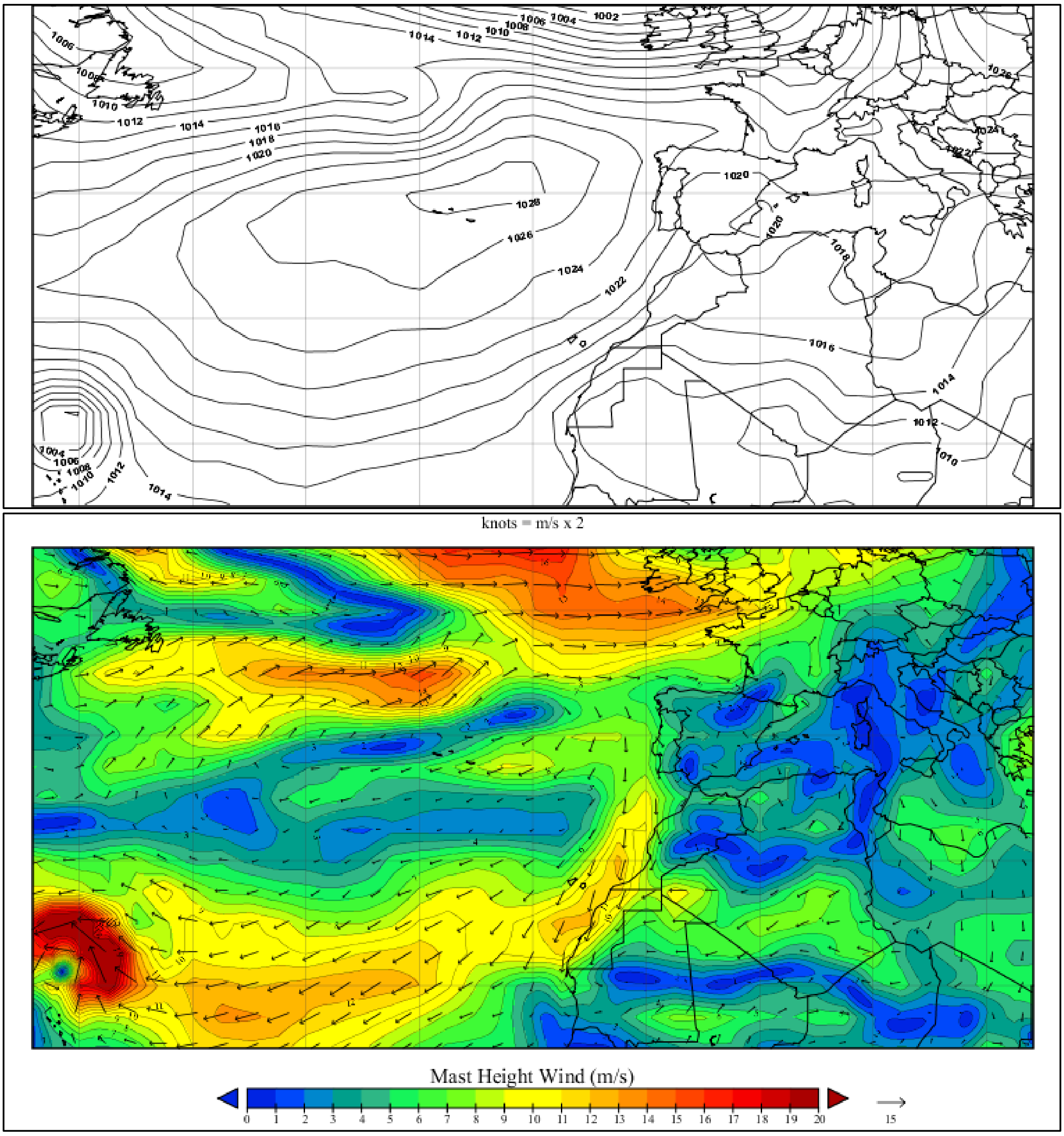


Fig 1.2.1.2: mean sea level pressure (hPa) (top)
and mast height wind velocity (m/s) (bottom) for 20th August 2009(5)

Another common occurrence is the NAH moving north to sit over the UK, which is great for weather there. This leaves the area south of the Iberian Peninsula in a synoptic no-man's land, with very little pressure gradient between the small heat low caused by the land mass of the Peninsula itself and the larger one generated by the Sahara Desert (*Figure 1.2.1.3).* In this case it generally pays to get further west, closer to the high and therefore in more gradient.

The heat lows can generate quite strong westerlies south of the Iberian Peninsula, but these are not so common at this time of year.

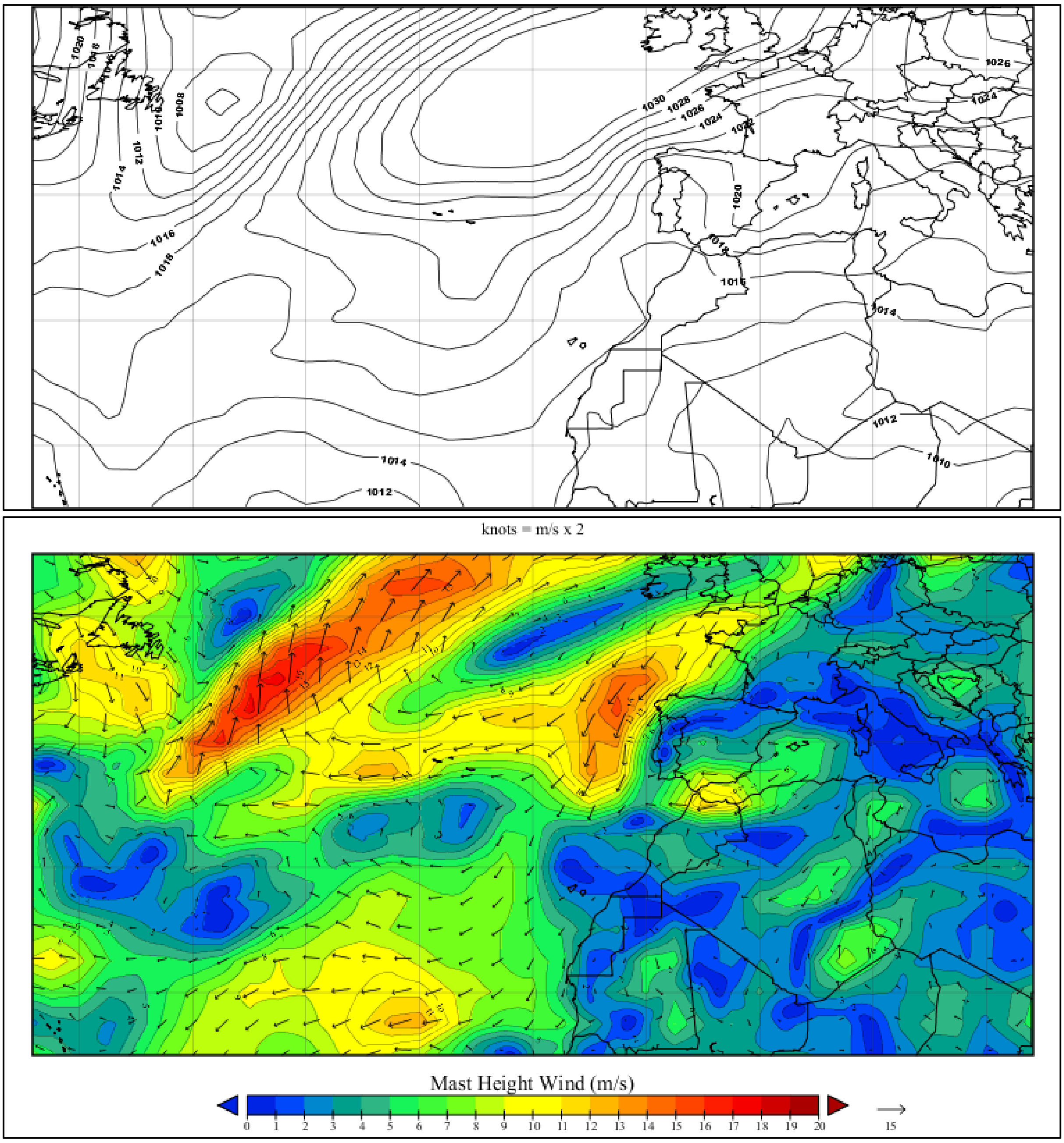


Fig 1.2.1.3: sea level pressure (hPa) (top)
and mast height wind velocity (m/s) (bottom) for 9th September 2009(5)

The third generalised scenario is that of the NAH being pushed south by a strong depression passing to the north. This effectively pushes a ridge directly over the route (*Figure 1.2.1.4)* and leads to further light winds. It is best to head slightly east of track in this case to pick up more breeze.

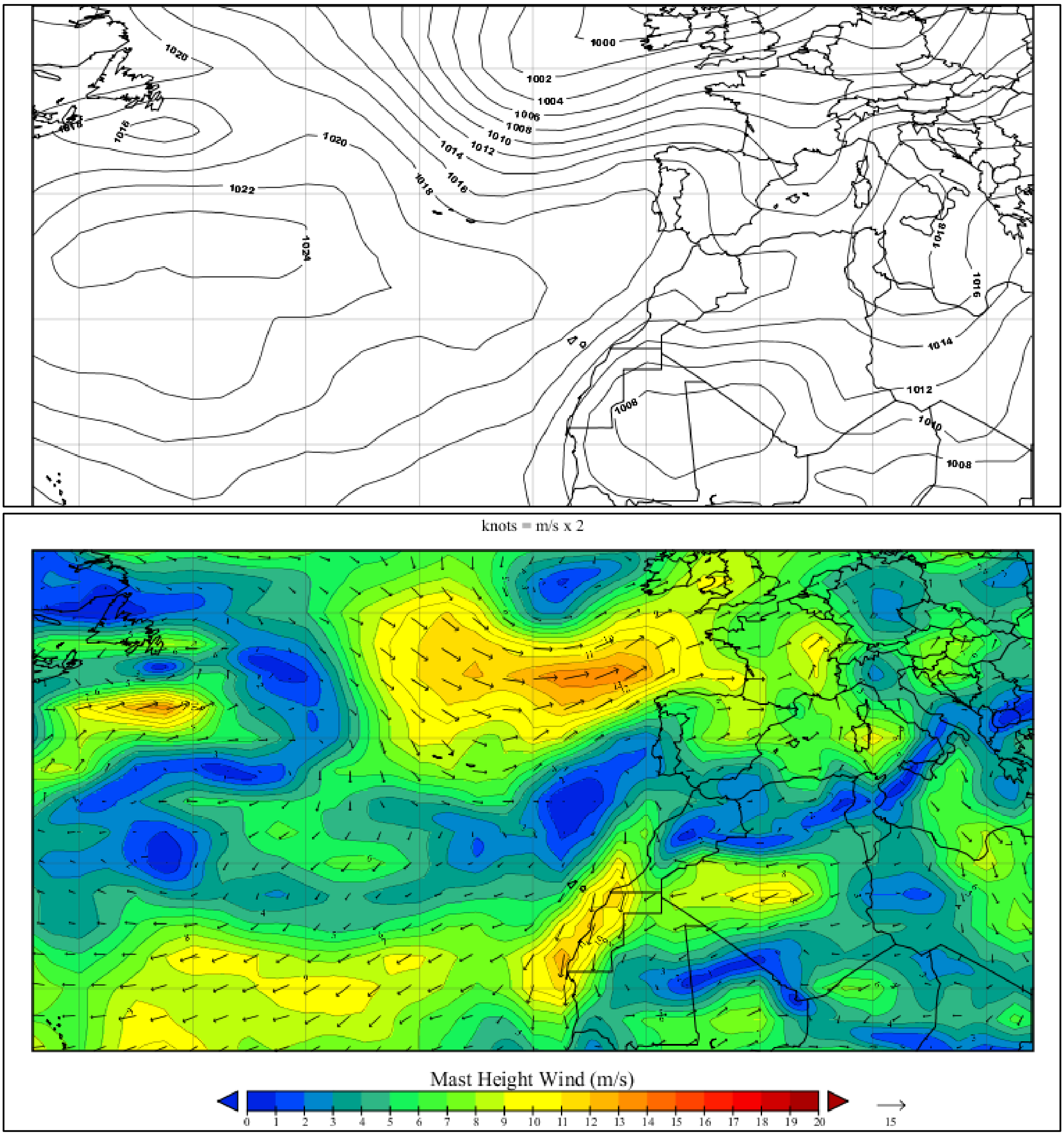


Fig 1.2.1.4: sea level pressure (hPa) (top)
and mast height wind velocity (m/s) (bottom) for 23rd July 2009(5)

1.2.2. The Canaries

The fleet will pass west, through and east of the Canaries, and some will gain while others lose badly in the changing local conditions there. The Canaries themselves are generally high volcanic mountains with impressive wind shadows – usually 25 miles to leeward of Gran Canaria, 15 miles to leeward of Isla de Tenerife and 30 miles leeward of Isla de la Palma (6). The islands also have significant wind acceleration zones, caused by the displacement of wind along and in between the islands (*Figure 1.2.2.1)*. These work by air being pushed to one side, and this air then combines with the steady flow between the islands – this then causes acceleration, as the only way to get an increased volume of air through the same gap is for it to speed up. This is not confined just to the Canaries, and will happen along any high obstruction or group of islands. The acceleration zones are a boon if they are expected, but also exist alongside the calm zones in the lee of the islands, and it is quite easy to stray from one to the other, so care must be taken. Visually the wind line on the water should be a good indicator – not so easy at night, however.

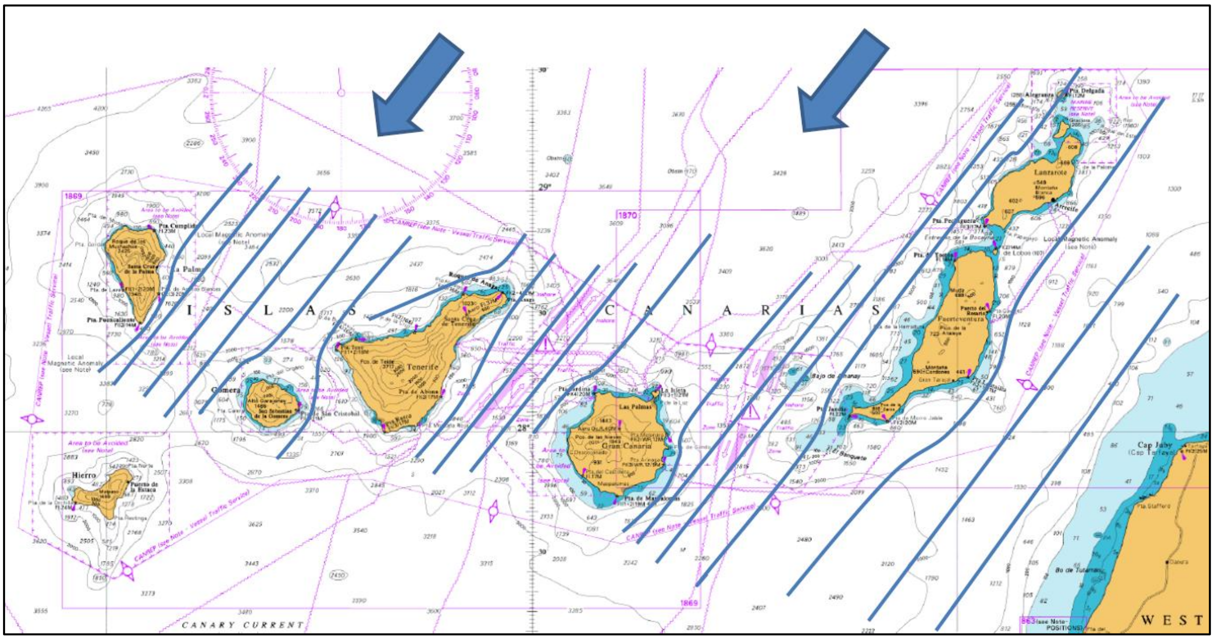


Fig 1.2.2.1: examples of acceleration zones through the Canaries with a NE wind, shown by the greater density of wind streamlines

There is an acceleration zone between the Canaries and the African coast for the same reasons. The choice of whether to go west, east or through is generally made for you by the circumstances of you race up to that point, and there are advantages and disadvantages to all three. It is important to try and pick your path to be as direct as possible, because once you start trying to hop from one route through to another it's likely that a lee will get you. Also the acceleration zones and lees depend on the wind at the time, the principles are the same though.

1.2.3. The Canaries to the ITCZ, via the Cape Verdes

Hopefully quite soon after leaving the Canaries behind you pick up the N or NE Trades which will take you down to the ITCZ. The historical data (*Figure 1.2.3.1)* shows this with the ITCZ occurring at about 10^{O}N, shown by the convergence of the SE and NE Trades.

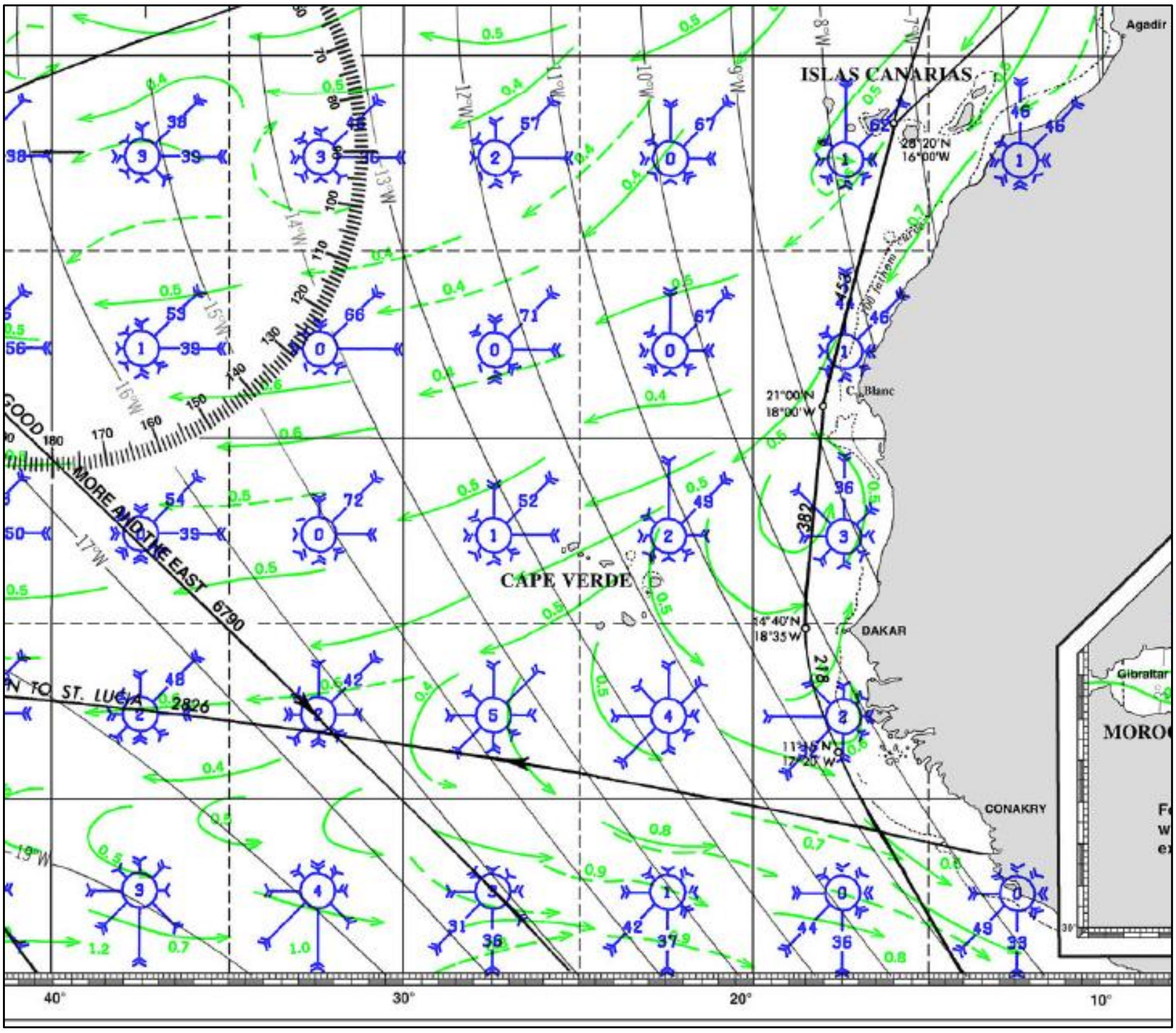


Fig 1.2.3.1: section of the North Atlantic Routing Chart for August (4)

Looking at the three general scenarios described in *Section 1.2.1* the winds are quite different for particular situations though (*Figure 1.2.3.2)*. With the NAH in the standard and southerly positions the wind seems strongest just to the east of the ideal great circle route, while with the NAH in the north the best winds are further west, away from the African continent. These snapshots of the wind vectors also show that the ITCZ itself seems thinnest at about 10^{O}N, 27^{O}W, which seems a fairly reasonable first approximation to line up for an Equator crossing at about 30^{O}W. The ITCZ does not lend itself to averages, though, and a good eye must be kept on the forecasts to help plan the passage through it.

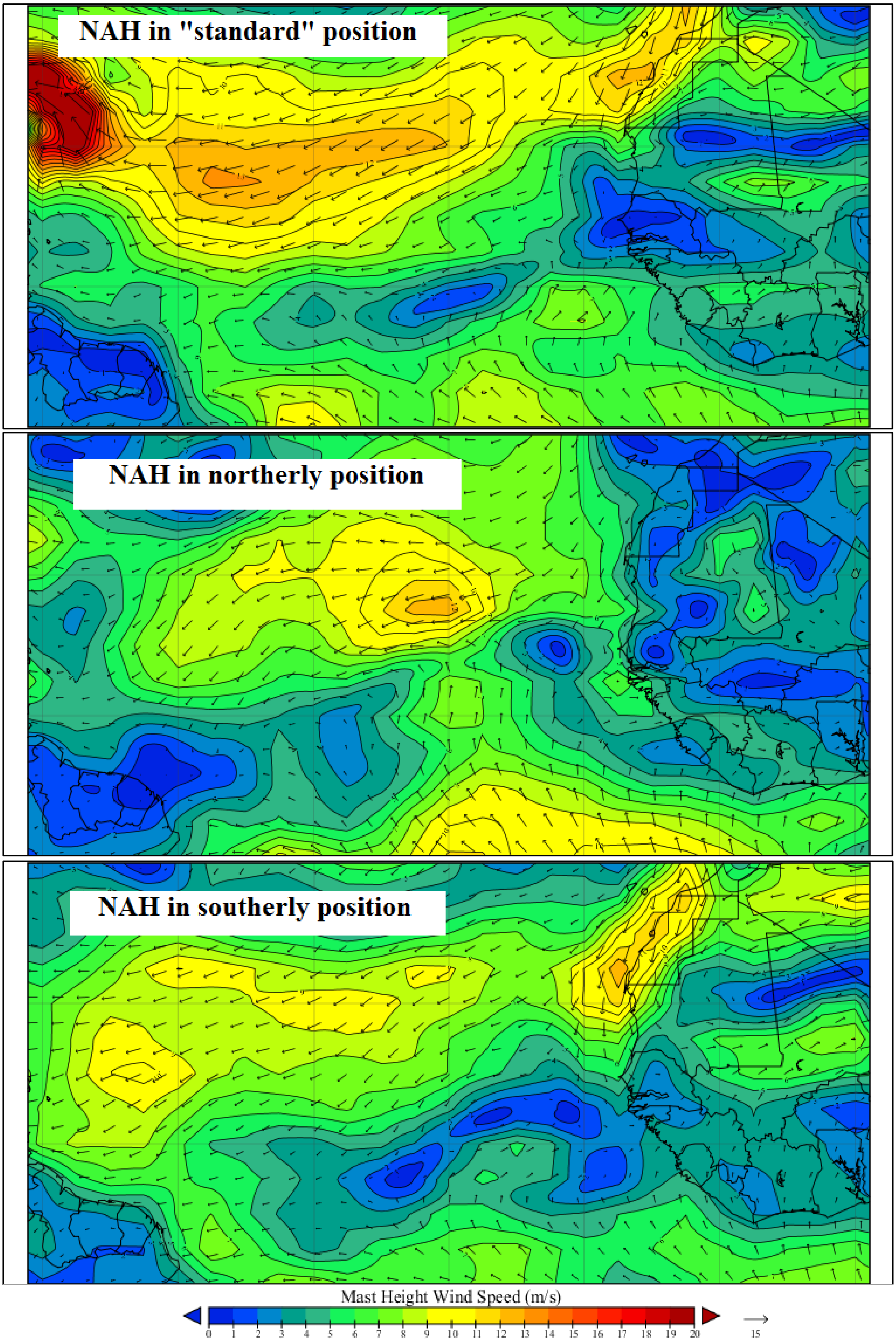


Fig 1.2.3.2: mast height wind vectors (m/s) for NAH in standard (top), northerly (middle) and southerly (bottom) position (5)

If the inshore route down the Mauritanian coast is chosen there may be some effect from local winds known as *Simoon* from the S to SE, or others from between E and S known as *irifi* (6). These occur generally in late summer or autumn, so it will probably be too early for them. The Cape Verde Islands are also on the route, and the same comments apply as for the Canaries, but to a lesser extent as the islands themselves are not as large and therefore do not have as big an effect on surface winds.

Local effects that will change the surface conditions are squalls (see *Section A.1)* and tropical waves which pass over every 2 or 3 days. These are effectively non-rotating depressions coming off the Saharan heat low and carried along by the west going mid level African Easterly Jet. They will make the wind back by about 20^{O} on average, then veer about 40^{O}, then come back to normal and there will generally be increased squall activity during them. They are well forecast on the EGC broadcasts.

1.2.4. The ITCZ in the Atlantic

This, as the name suggests, is the convergence zone for the NE Trades and the SE Trades. At this time of year it will be around 8^{O} to 10^{O}N, but it is by no means stationary, moving upwards and downwards every few days as the large ocean highs also move up and down. As it is a convergence zone the air coming in has to go somewhere, and this is generally upwards, with warm moist air rising to form large convective clouds (*Figure 1.2.4.1).*

Fig 1.2.4.1: ITCZ convective clouds in the North Atlantic (Frank Everaert, 2003)

There are almost always breaks in this convection, though, seen by comparing the thermal infra-red (TIR) satellite image with the surface winds for a typical NAH situation (*Figure 1.2.4.2)*. TIR images are brightest with colder and hence higher clouds, so the really big convective clouds are shown as white, the grey ones are low to mid-level clouds. The widest areas of little wind are characterised by the widest areas of high cloud.

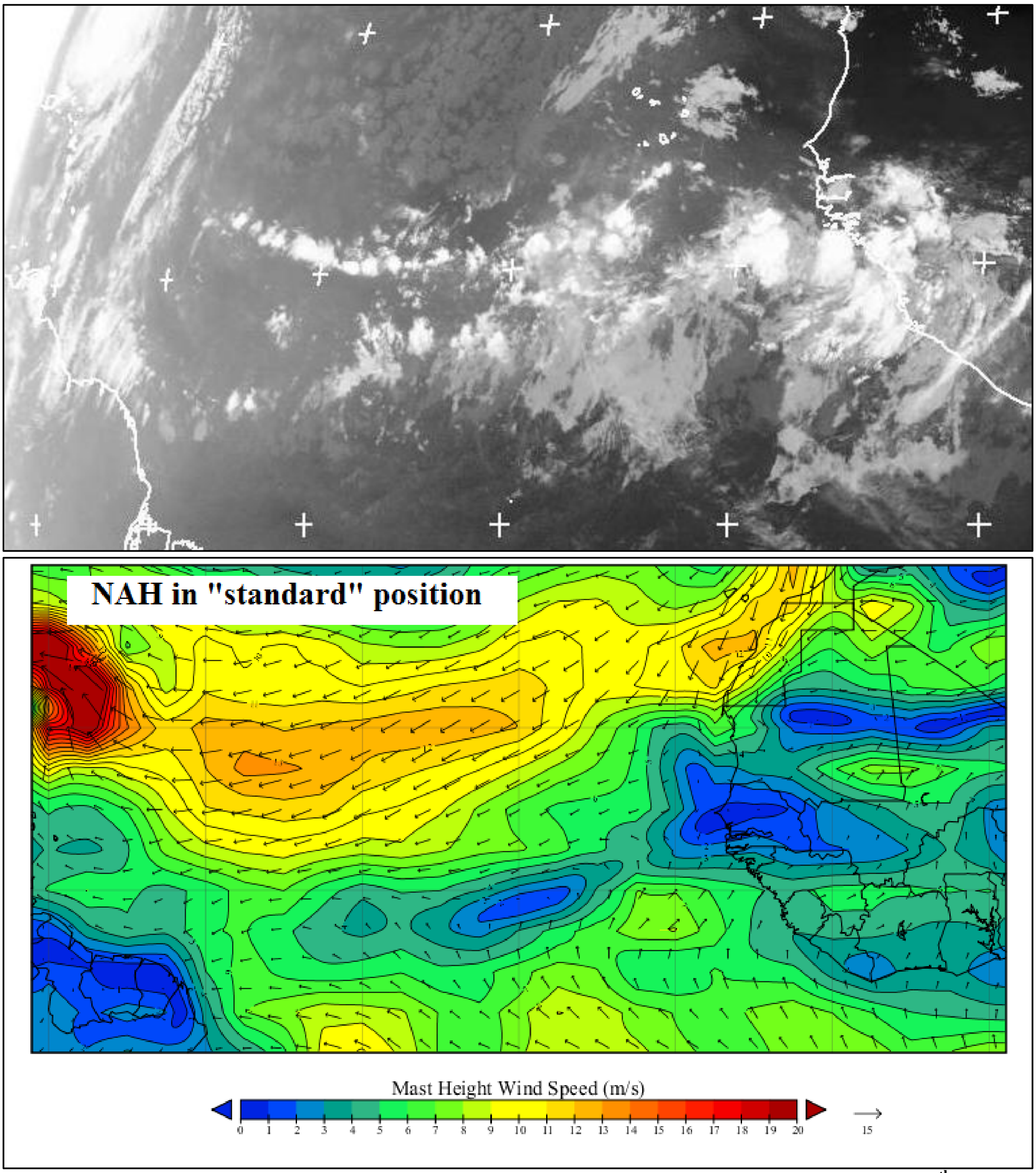


Fig 1.2.4.2: the ITCZ in TIR (top) (7) compared with surface winds (bottom) (5) for August 20th 2009

The TIR image also shows high level wisps of cloud to the north and south of the main convection. These are scraps of cloud being carried polewards by the upper level winds of the Hadley Cell, shown as part of the idealised global circulation pattern (*Figure 1.2.4.2*). This looks quite strange from the surface, as these upper level wispy clouds will be going the opposite direction to the surface wind. This is generally a sign that you are less than about half a day from the ITCZ, as the moisture in these very cold clouds is soon gone.

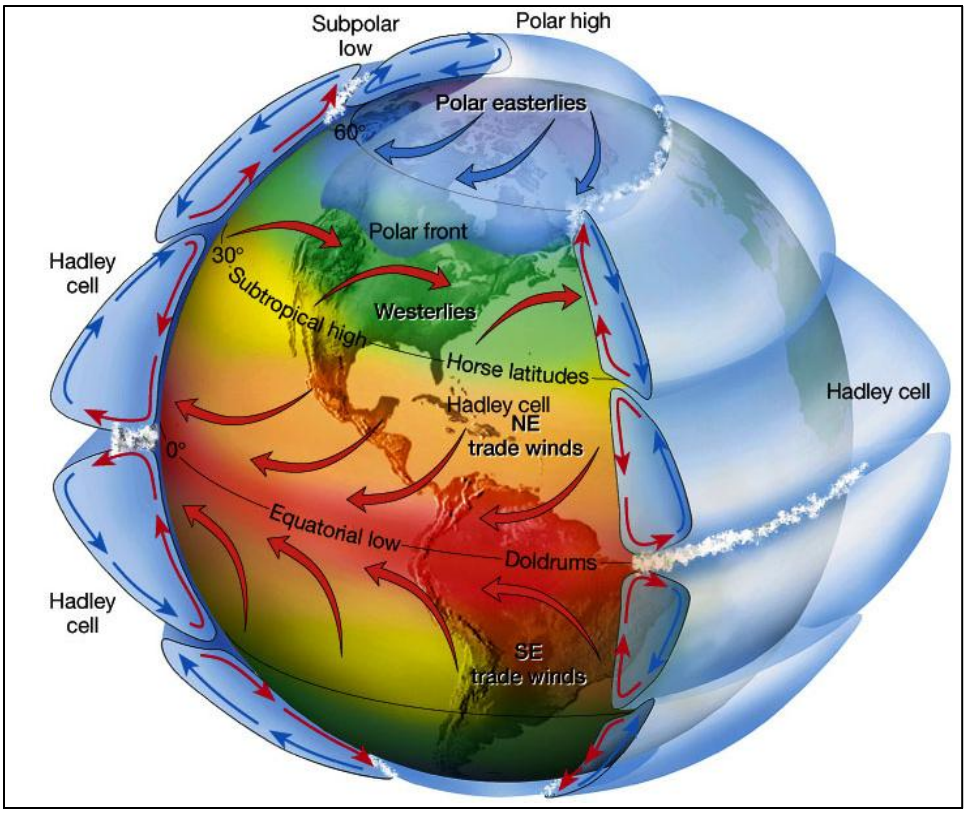


Fig 1.2.4.3: idealised global wind circulation (8)

Once in the ITCZ the winds are very changeable, often being driven by gusts coming down from squall clouds and small local circulations. The only way to deal with it is to keep trimming and changing sails as required, and also to throw out the window normal concepts of leeward and windward – a squall can approach from your leeward side as the wind may be completely different over there.

The best place to get information on the position of the ITCZ at sea is to follow it via the EGC messages on SAT-C and to look at the convergence patterns on the GRIB files. MetArea II gives this information, as well as the location of all the lows, highs, fronts, etc. This is very useful, and should ideally be drawn out daily to give you a visual picture of what's going on. The best scenario is to cross the ITCZ when it is moving north – this way your time in it is minimised.

1.2.5. The ITCZ to Cabo Frio

The routing chart (*Figure 1.2.5.1)* shows the main tactical dilemma of this section. Generally the further west you are the smaller the ITCZ, but if you go too far west you will have too much of a beat from the ITCZ to about 5^{O}S, which is not helped by the consistently west-going current. An ITCZ crossing at about 27^{O}W will allow you to initially beat and then fine reach down to the tip of South America.

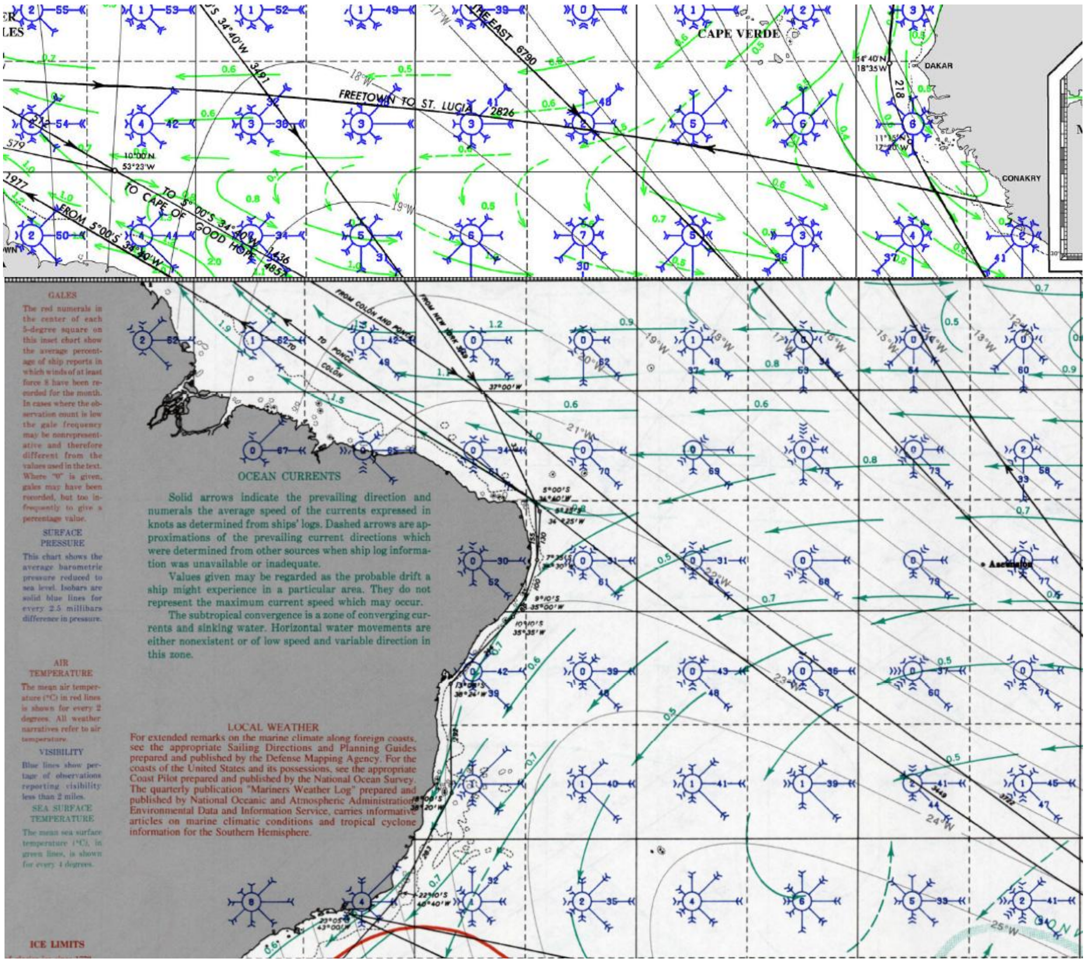


Fig 1.2.5.1: a composite of extracts of pilot charts for the N and S Atlantic for September (4)

Three mast height wind snapshots (*Figure 1.2.5.2)* are shown with the NAH and hence the ITCZ in "standard", northerly and southerly positions, and it can be seen that once the influence of the ITCZ is left behind the wind direction is very similar from The ITCZ to Cabo Frio, with differences in wind speeds but not appreciably in direction. This does also show that tactical gains are far more easily made, and lost, north of the ITCZ. South of this it mainly comes down to boat speed.

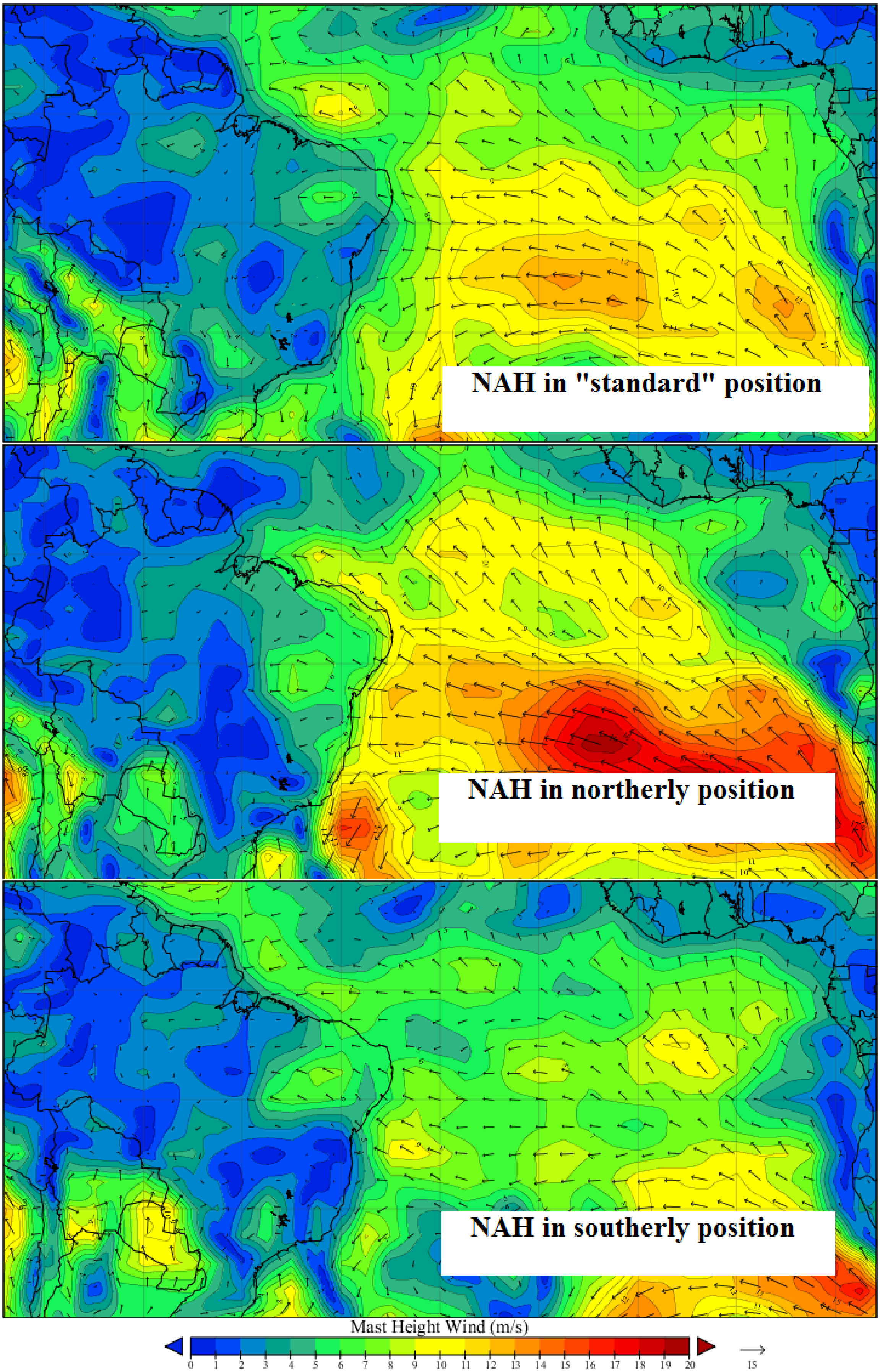


Fig 1.2.5.2: mast height winds (m/s) with the NAH in "standard" (top), northerly (middle) and southerly (bottom) positions (5)

Low pressure systems are also formed in the Parana basin region of Brazil south of Rio de Janeiro. These move SE into the South Atlantic to the north of the Rio del Plata, and are known as *Sudestada*. They are characterised by strong SE winds, and may drag a front over the very southern part of this section (9). They approach quickly and, as with the ITCZ, a good warning of them comes from the SAT-C EGC messages for MetArea V. Also, thunderstorms are common in September (9). *Sudestada* and will be more common towards Rio, thunderstorms more common in the warmer waters to the north. Once round the corner of Cabo Frio into Rio itself it's down to heading for home with whatever local weather gives you.

1.3. Currents

1.3.1. The Iberian Peninsula to the Equator

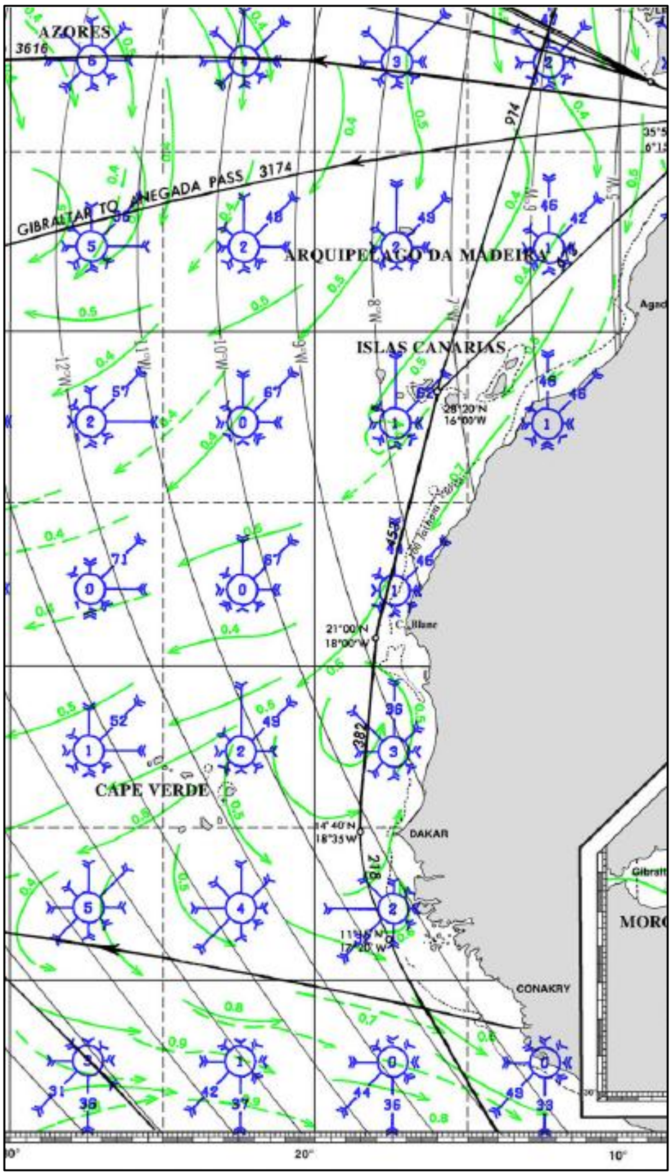


Fig 1.3.1.1: pilot chart extract for August (4)

The general trend is for a favourable current of approximately 0.5 to 0.7 knots (6), and the routing chart (*Figure 1.3.1.1)* shows that there is potentially more current closer to the African coast, with 0.7 knots in between the Canaries and the coast of Mauretania. This is also borne out by the 5 day mean centred on August 27th 2009 *(Figure 1.3.1.2)*, where even though the coastal data is not shown completely it can be seen that there is a faster stream to the east, and to the west, of the Canaries. This 5 day mean also shows the less ideal actual surface flow, with the general southerly flow made up of a series of eddies.

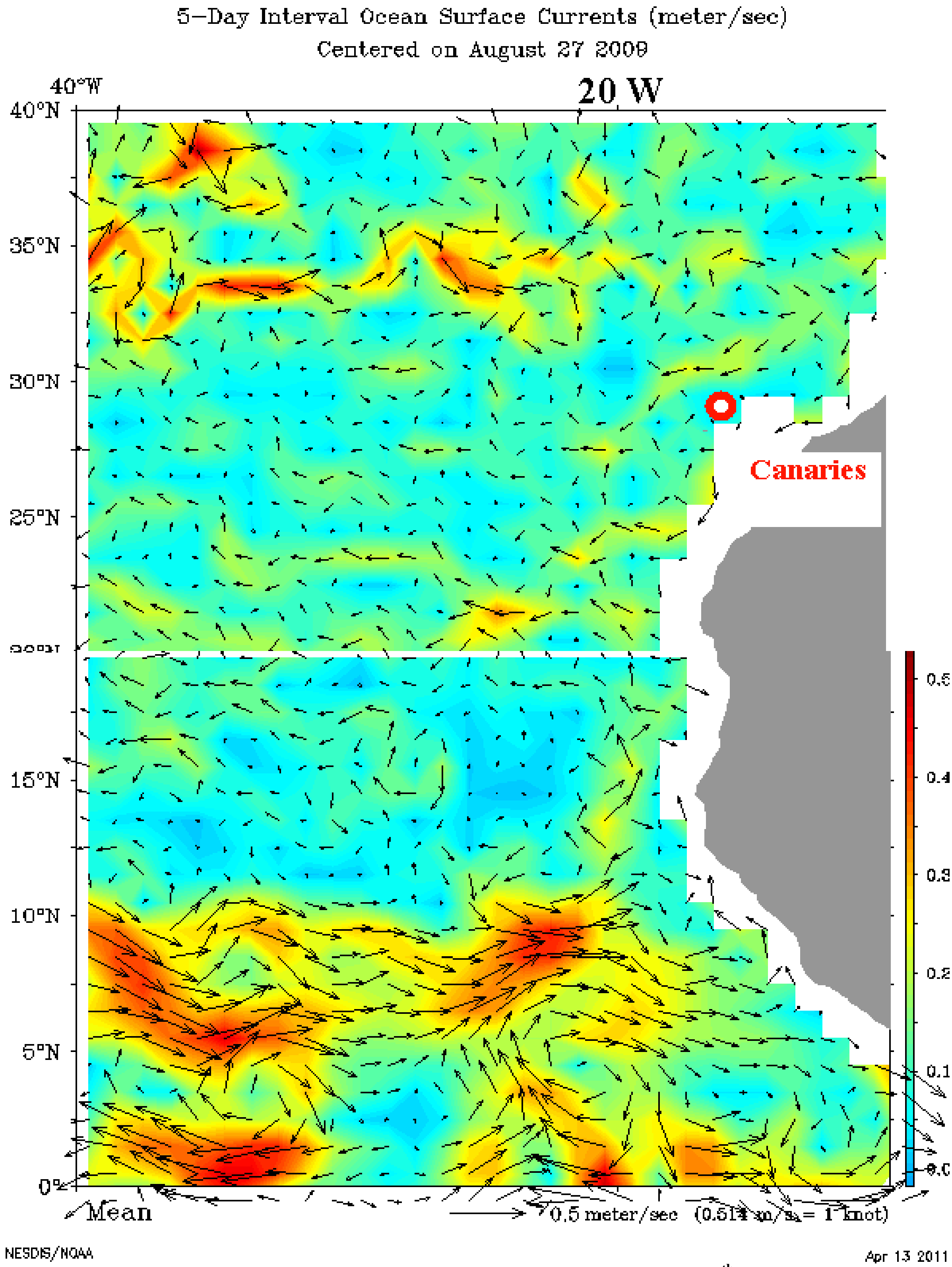


Fig 1.3.1.2: 5 day mean of surface currents centred on August 27th 2009 (10)

The Equatorial counter current at 5^O to 10^{O}N on the routing chart is shown well on the 5 day mean, and indicates how consistent this is.

1.3.2. The Equator to Rio

The routing chart (*Figure 1.3.2.1)* shows favourable and consistent current all down the South American coastline, and this is illustrated by the 5 day mean centred on September 6th 2009 (*Figure 1.3.2.2)*. The strongest current will be found at the edge of the continental shelf, generally at about the 200m contour. There are also weak countercurrents inshore in the larger bays (9).

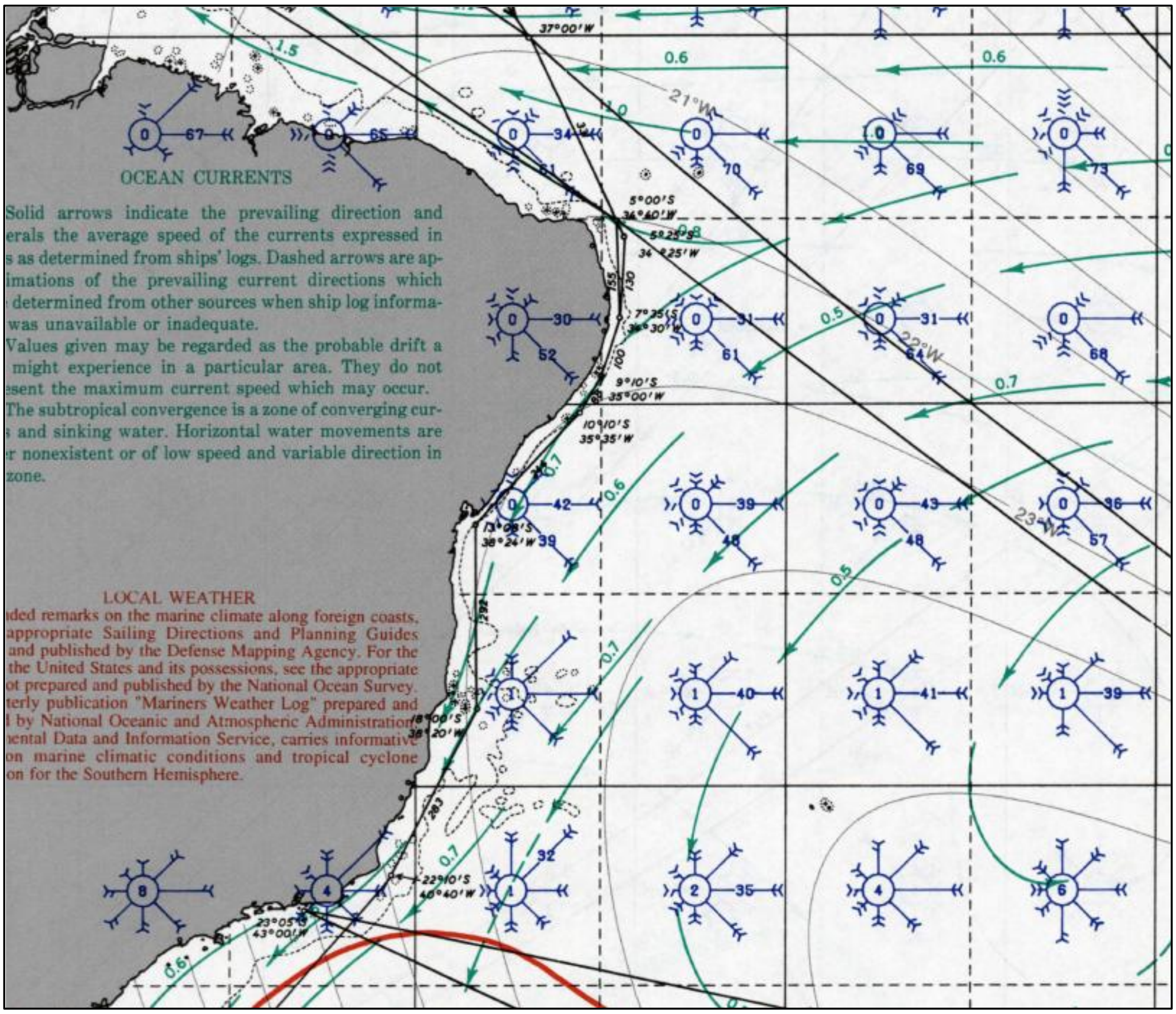


Fig 1.3.2.1: extract from the pilot chart for September (4)

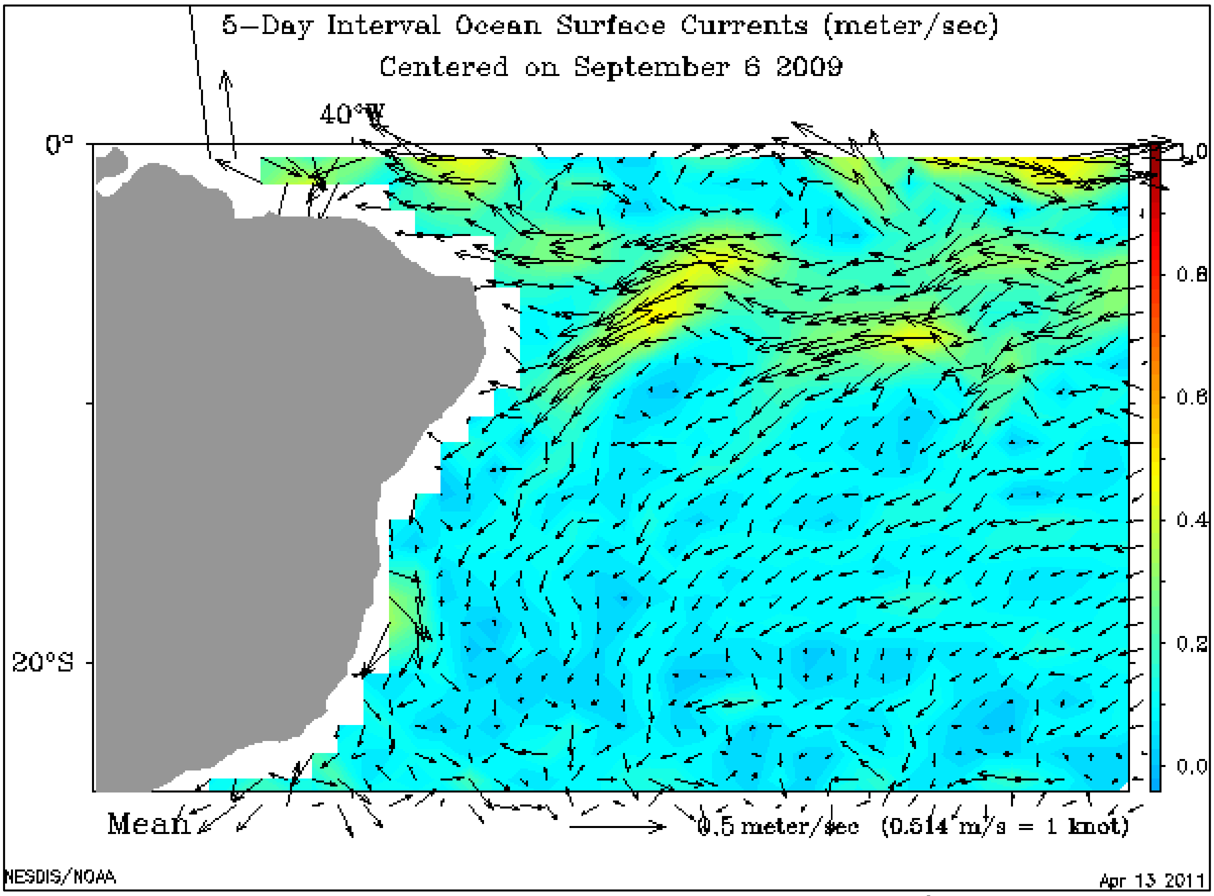


Fig 1.3.2.2: 5 day mean of surface currents centred on September 6th 2009 (10)

2. Leg 2 – Rio de Janeiro to Cape Town (mid September to mid October)

2.1. The Route

Navigationally this is one big great circle leg, with nothing in the way once Rio is left behind (*Figure 2.1.1).* In practice the prevailing and particular weather will adjust things somewhat.

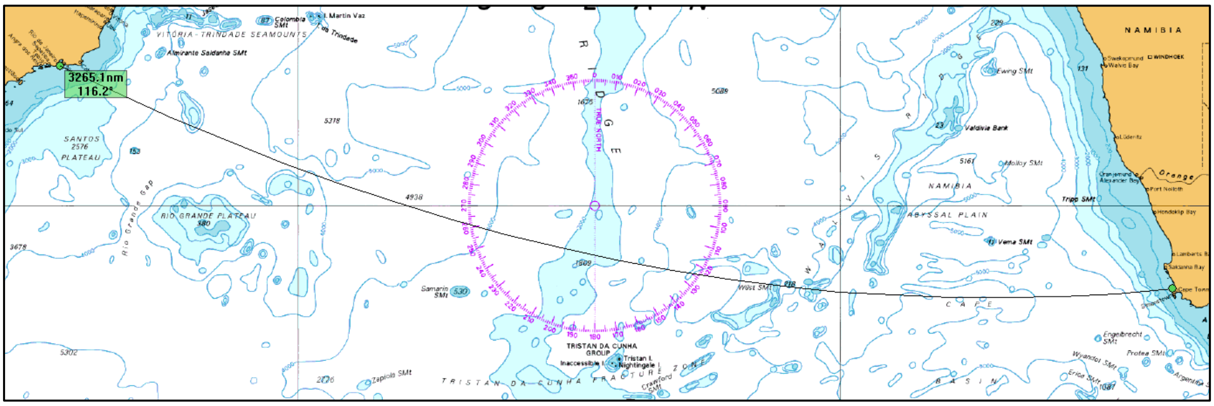


Fig 2.1.1: Rio de Janeiro to Cape Town showing the great circle route (11)

2.2. The Weather

The initial thought would be to gracefully go around the South Atlantic High (SAH), ending up after three weeks of glorious downwind sailing in Cape Town. Sadly, this doesn't happen. The main reason for this is the convergence of the cold Antarctic air from the south with the warm subtropical air from the north, which is labelled "Subtropical Convergence" on the routing chart (*Figure 2.2.1).*

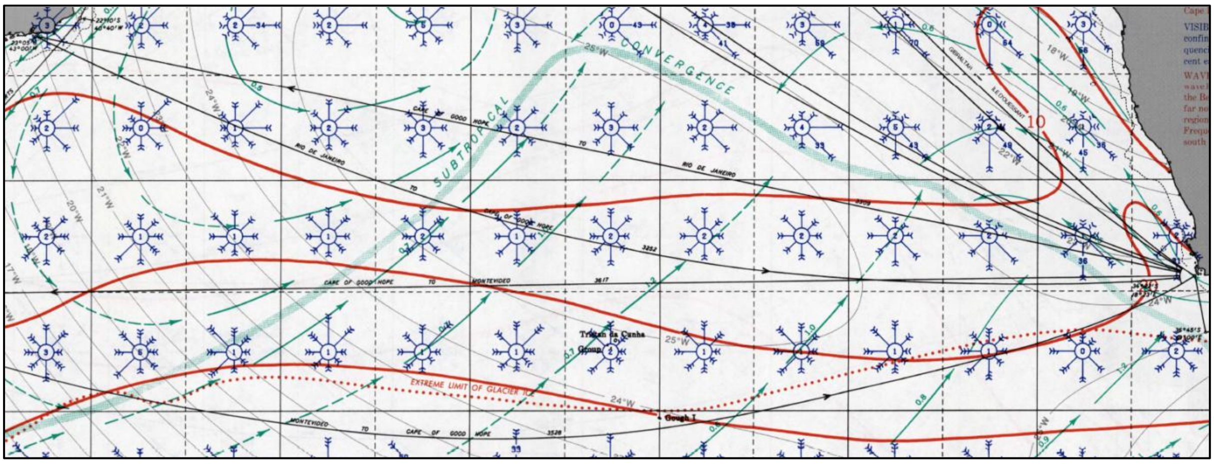


Fig 2.2.1: extract from the routing chart for October (4)

The Southern Ocean is the only ocean with an unimpeded global track, and this allows the lows to encircle Antarctica like terrible jewels on a necklace of the gods, ever circulating, growing, dying and growing again (*Figure 2.2.2).*

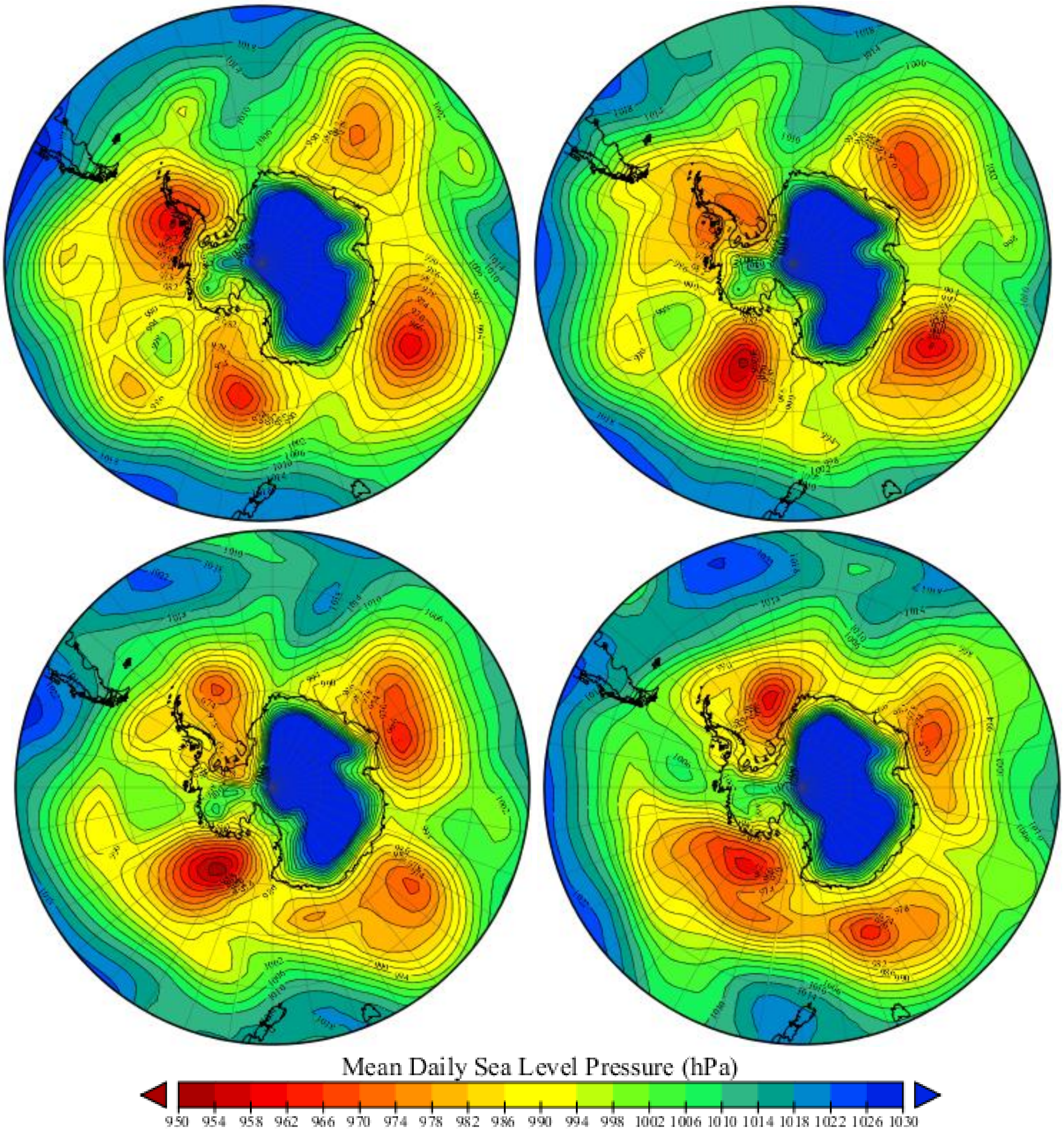


Fig 2.2.2: low pressure systems (red) circulating the Antarctic polar high on 4 successive days (16th to 19th September 2009, top left, top right, bottom left, bottom right) (5)

Apart from allowing flowery prose, these deep lows sweep strong fronts up the South American coast and then across the bottom of the SAH, which can develop strong secondary depressions. As these fronts pass over the winds will go from NE to N then back rapidly to the SW or S.

Another local effect is that of the *Sudestada*, which describes the formation of lows inland in Brazil which then move SE into the S Atlantic, giving headwinds leaving Rio (*Figure 2.2.3).* This also shows the SAH being squeezed and deformed by the *Sudestada* and the deep Southern Ocean low to the south.

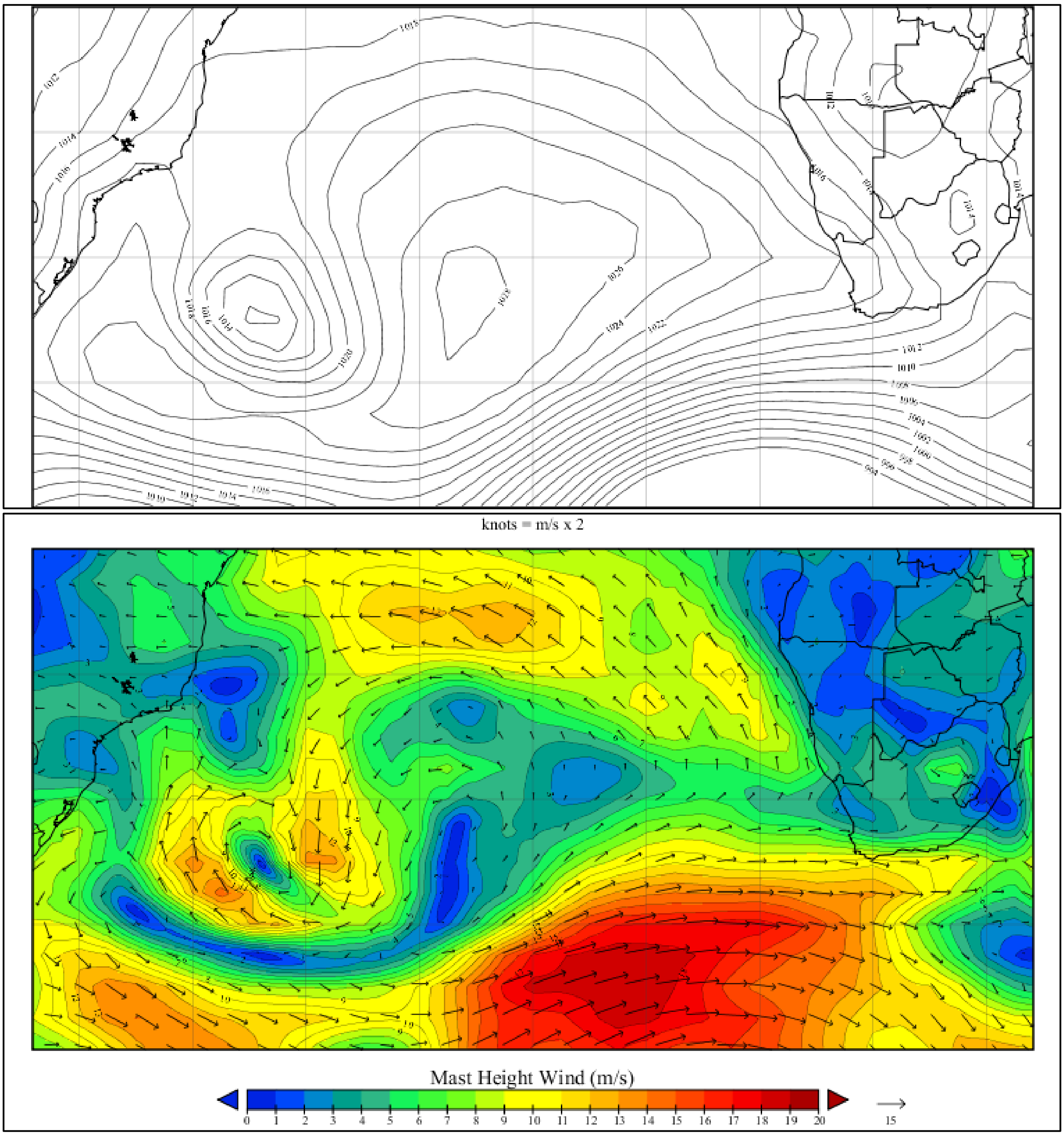


Fig 2.2.3: mean sea level pressure (hPa, top) and mast height winds (m/s, bottom) showing a Sudestada low just moving into the S Atlantic SE of Rio de Janeiro, 15th September 2009 (5)

As the SAH re-establishes itself decent westerlies can be found at about 32^{O} to 35^{O}S (*Figure 2.2.4).*

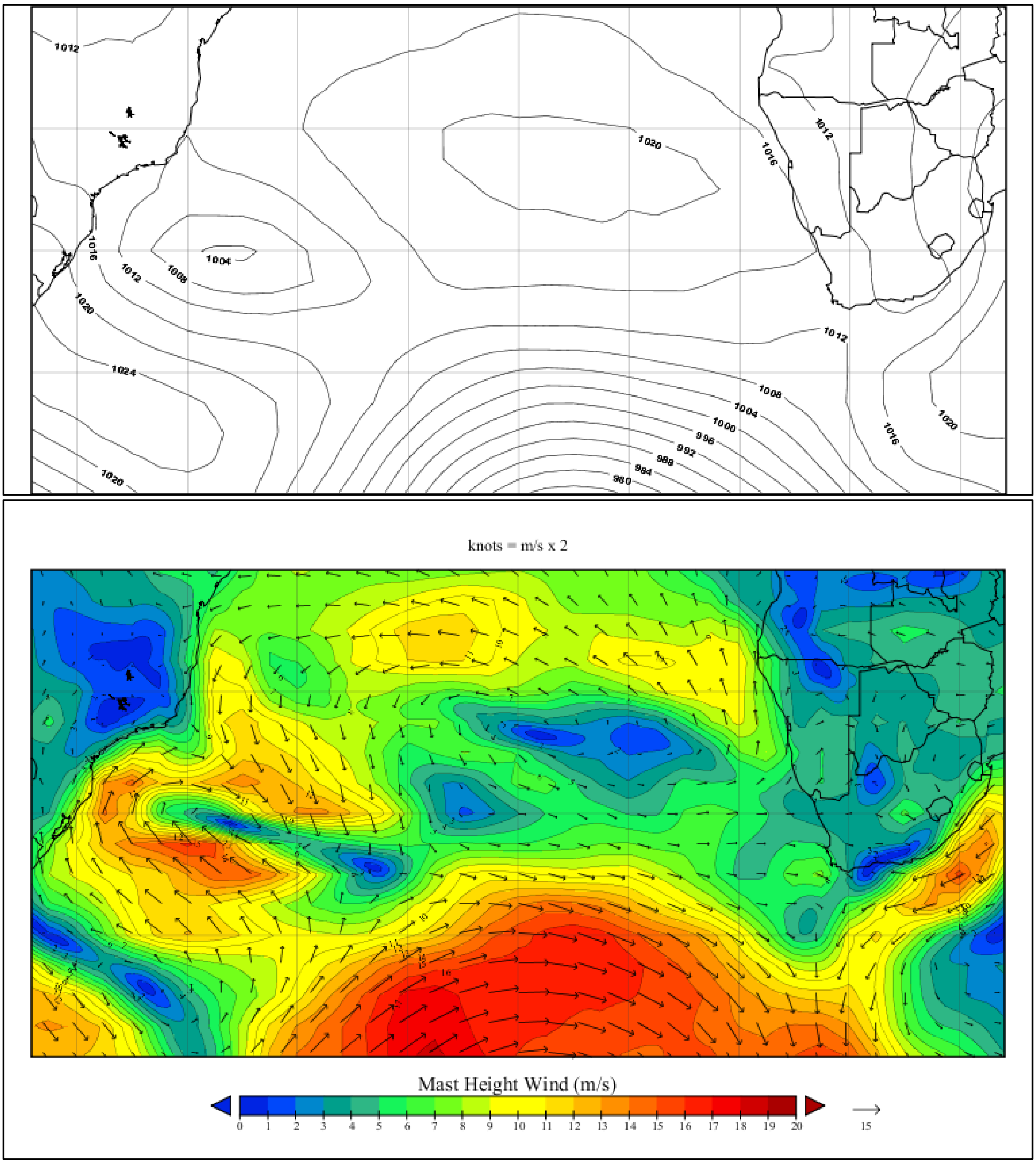


Fig 2.2.4: mean sea level pressure (hPa, top) and mast height winds (m/s, bottom) showing the SAH re-established at about 26^{O}S giving steady westerly winds, 24th September 2009 (5)

The SAH will often move down to the SE and intensify to form a blocking high (*Figure 2.2.5)* giving either light or contrary winds. Looking at the dates of these examples it can be seen that the situation south of the SAH is constantly evolving, and careful monitoring of the GRIB files, synoptic charts and EGC messages (MetAreas V, VI and VII) is essential to be able to monitor the changes and respond to them.

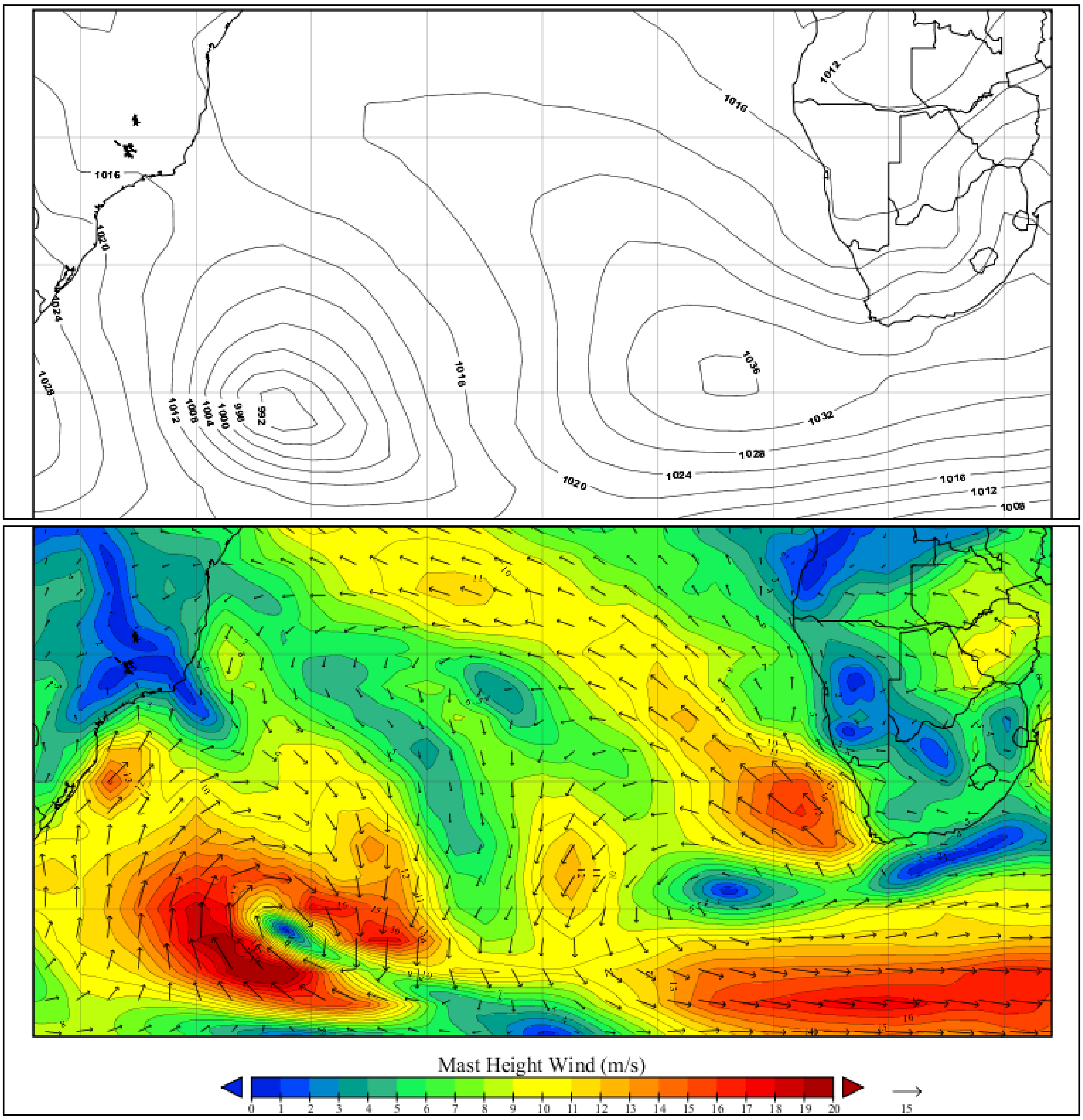


Fig 2.2.5: mean sea level pressure (hPa, top) and mast height winds (m/s, bottom) showing the SAH increased and shifted to the SE, 29th September 2009 (5)

Closing into Cape Town itself the effect of cold fronts from depressions to the south can be severe, giving rise to the local term "southerly buster" which is somewhat descriptive, with strong southerlies of gale force or more building very quickly. In a SE wind, there is often a calm in the lee of Green Point at the southern side of the harbour.

2.3. Currents

This part of the South Atlantic is just to the north of the South Atlantic Confluence region, where the warm water coming southwards as the Brazil Current meets the cold water coming northwards after spreading out through the Drake Passage between South America and Antarctica. The snapshot of syrface current over sea surface temperature (SST) shows this (*Figure 2.3.1)* and also shows the distinctly non-linear flow at any particular day, with eddies appearing at quite a large scale.

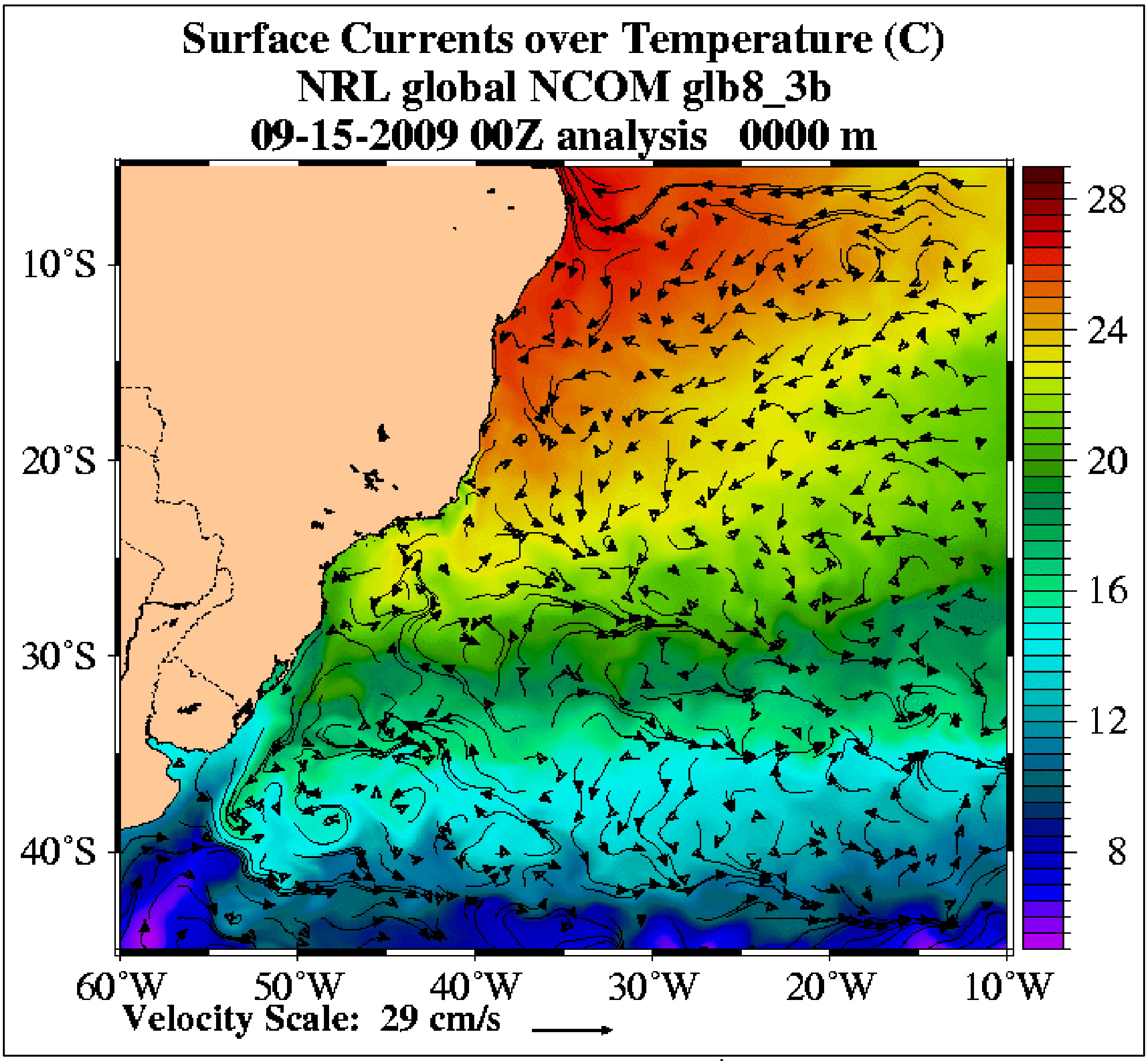


Fig 2.3.1: surface currents (cm/s) over SST for 15th September 2009 (12)
To convert cm/s to knots, divide by 100 and multiply by 2

Over a relatively short period of time the eddies will average out, however, and there is definitely some order to the overall flow. The 5 day mean shows very similar flow to the monthly mean for September 2009 (*Figure 2.3.2)*, with a distinct advantage in moving from 32^{O}S to around 35^{O}S at about 22^{O}W.

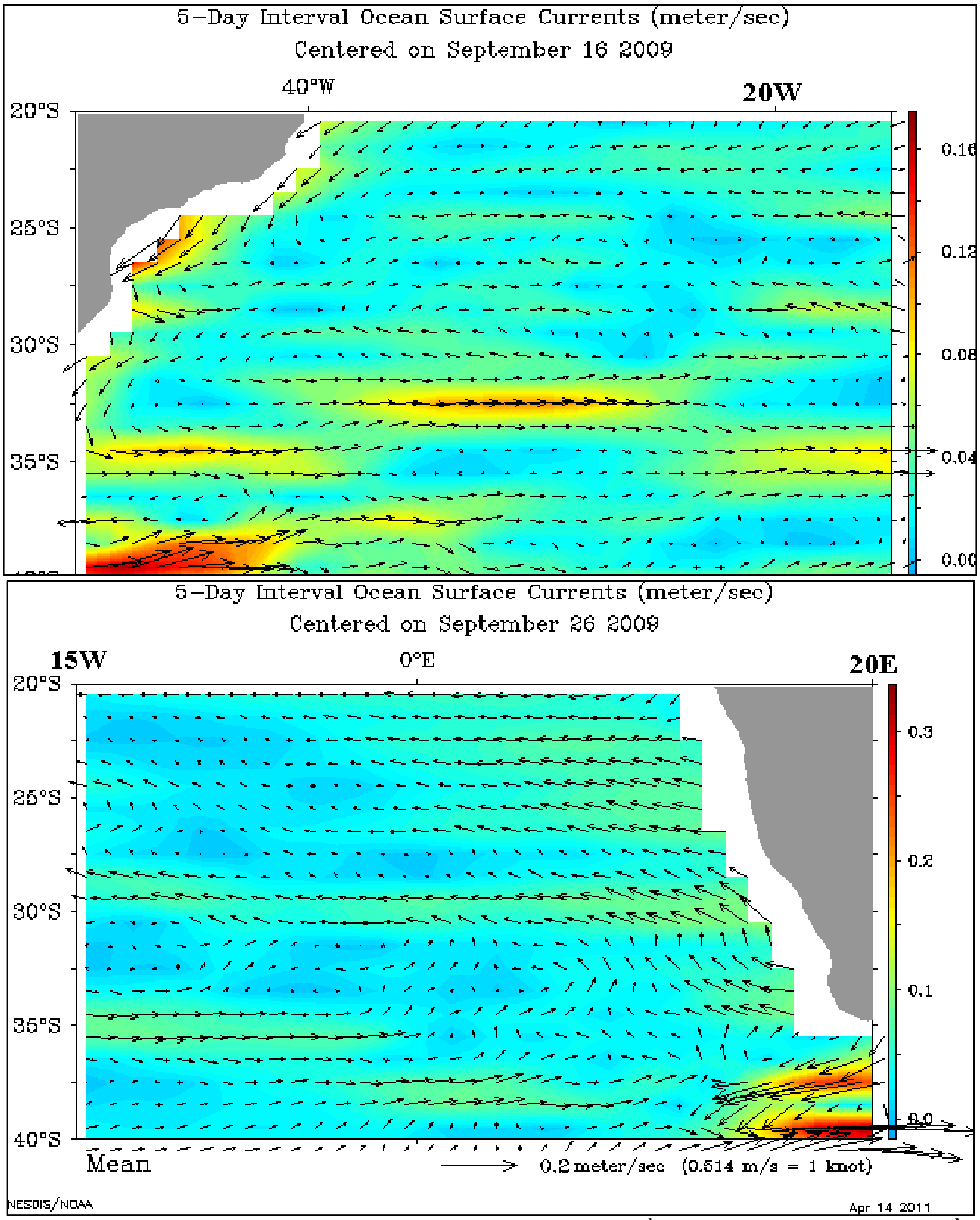


Fig 2.3.2: surface currents (m/s) for 5 day means centred on 16th September 2009 (top) and 26th September 2009 (bottom) (10)

The Benguela Current, a cold current, moves to the north along the South African coast, but in general as you approach the coast from the west the current mostly pushes you to the north rather than east or west to any great degree.

3. Leg 3 – Cape Town to Western Australia (October to November)

3.1. The Route

Typically this will go southwards at first to get past the Aghulas Bank with its contrary currents and in to the steady westerly winds (*Figure 3.1.1).* The great circle route shown then goes down close to the Kerguelen Islands, and the southwards limit is certain to be set north of this for the race itself.

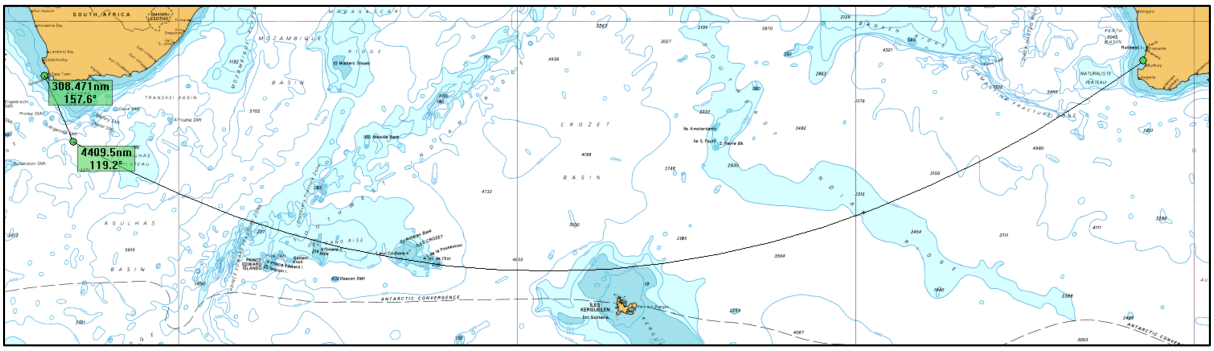


Fig 3.1.1: composite great circle route from Cape Town to Western Australia (13)

The previous Clipper race fleet tracks show this well – an initial dive south, then onwards to the east (*Figure 3.1.2).*

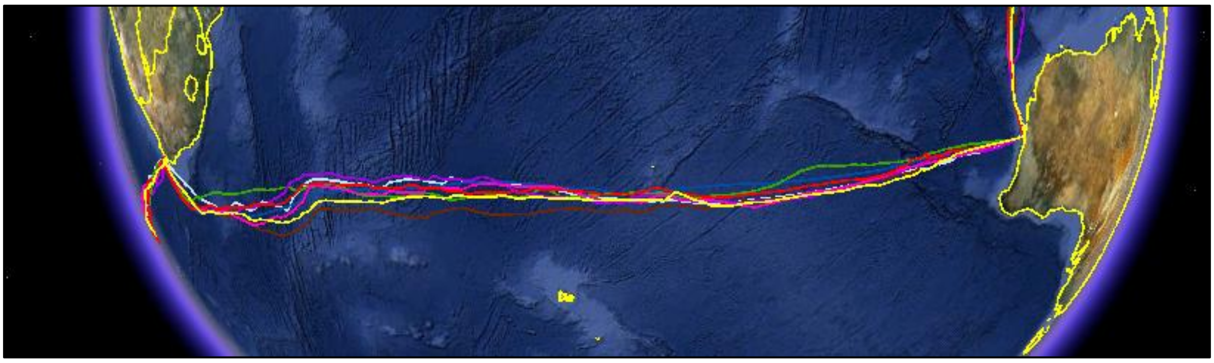


Fig 3.1.2: Clipper 09-10 fleet tracks from Cape Town to Western Australia

The routing charts (not shown) indicate that there are consistent westerly winds and east going currents south of about 39^{O}S for the crossing, but to make best use of these the synoptic characteristics show a more complicated view.

3.2. The Weather

The progression of lows around Antarctica *(Figure 2.2.2)* obviously drives the weather in the Southern Indian Ocean too. There is a significant difference between the Southern Indian and the South Atlantic Oceans though, in that the Southern Indian Ocean is much larger and this allows the nature of the Indian Ocean High (IOH) to be modified more. The best way to describe this is to look at an example of the conditions over a few days (*Figures 3.2.1 to 3.2.3).* These snapshots are there to show typical scenarios.

The IOH is not a single steady synoptic entity, and tends to slowly move eastwards across the Southern Indian Ocean. It often splits in two, particularly with a strong depression polewards of it, and the transition from one cell to the next provides the trickiest navigational dilemma. The weakest winds occur in between high pressure systems particularly with a trailing cold front passing over, for example at 38^{O}S, 55^{O}E on October 19th (*Figure 3.2.2).* If the low pressure system polewards of this in-between area is past to the east then the area of light winds can extend and even turn into an area of cyclonic rotation, a secondary low, giving headwinds.

Areas of significantly stronger winds occur as you would expect when the faster moving lows are squeezed up against the poleward side of the highs causing significantly higher pressure gradients and therefore winds.

To stay in consistent westerlies a constant balance needs to be struck between going too far south into the very strong winds, and too far north into the anticyclonic light winds at the edge of the high. This is complicated by the fact that the stream of consistent westerlies moves to the north and south with the passage of the necklace of lows around Antarctica. From an armchair meteorological point of view as a low approaches from the west it would seem prudent to be heading northwards on port gybe to be north of the strongest winds, and as the low departs to the east to be on starboard gybe heading southwards to avoid being caught in the area of light winds between systems. This approach, of course, takes no account whatsoever of the practical factors that will also affect the choice of course, and also does not take into account the fact that diving a few degrees south to stay in westerlies may leave you totally exposed to the next low. It may well be the sensible choice if the westerly wind band dips far south to actually sail into the southern part of the high and just go slowly – much more preferable to incurring significant damage or worse just to catch better breeze for a day or two.

October 17th 2009 (*Figure 3.2.1)*: the IOH is a single defined system, and the SAH is pushing over Cape Town, giving light head winds (as happened at the 09/10 restart here). Apart from in the IOH itself there are good westerlies south of about 37^{O}S west of the IOH, and south of about 39^{O}S east of it.

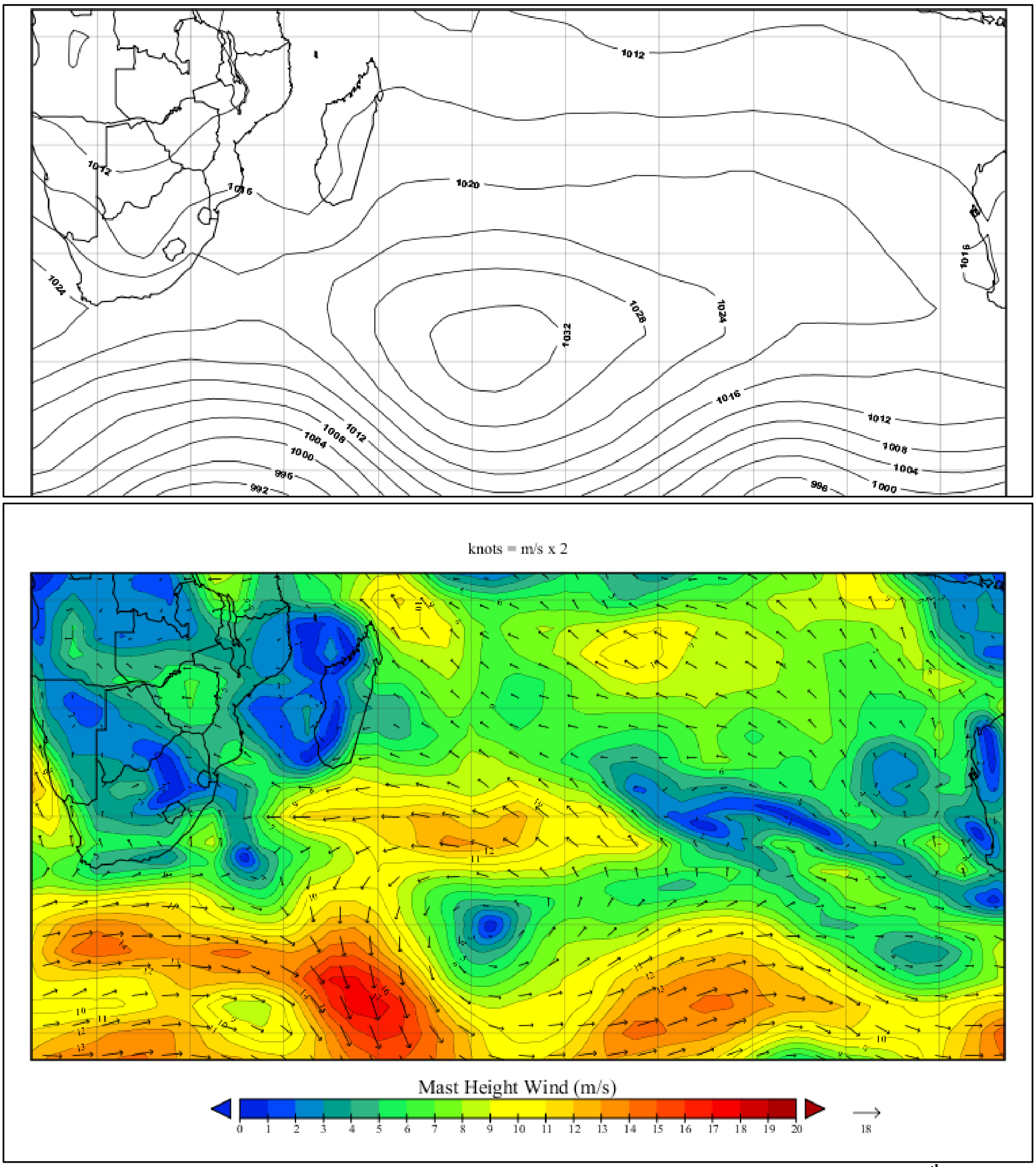


Fig 3.2.1: mean sea level pressure (top, hPa) and mast height wind (bottom, m/s) for October 17th 2009 (5)

October 19th 2009 (*Figure 3.2.2)*: the main IOH has been pushed towards Australia, and the cell that was over the South Atlantic has moved into the Southern Indian Ocean. Seen from the shape of the isobars and the change in direction of the wind there is a front going to the SE of about 38^{O}S, 55^{O}E – this front is being trailed back from a deep low and the part where trails over the transition zone between the two high pressure cells is an area of very low wind and probably rain too. This trailing cold front transition zone is one to be avoided, and if one is on the way try and get south as even half a degree can make the difference between a zephyr-like 3 knots of breeze and a much more useful 6 knots.

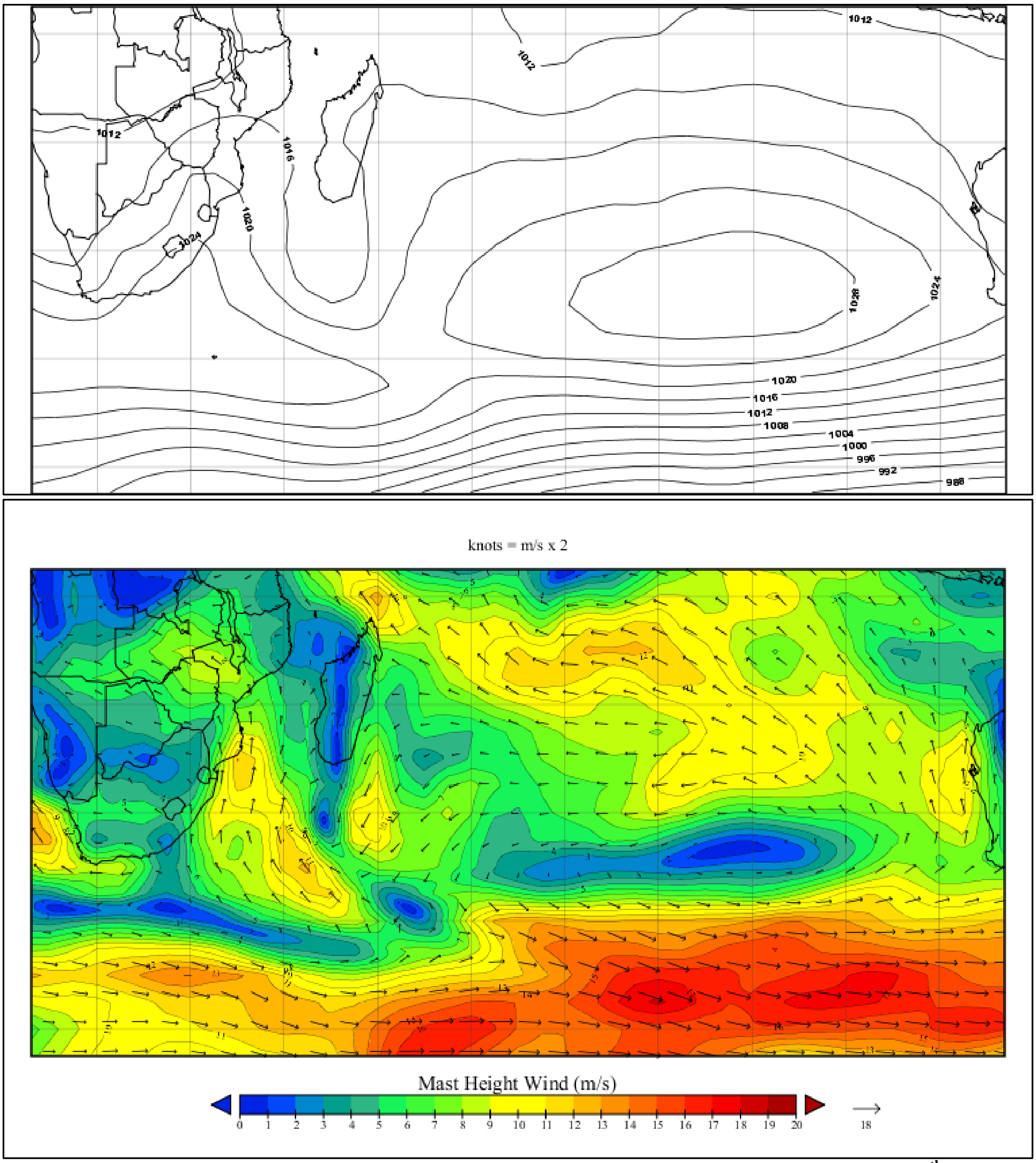


Fig 3.2.2: mean sea level pressure (top, hPa) and mast height wind (bottom, m/s) for October 19th 2009 (5)

October 23rd 2009 (*Figure 3.2.3)*: this is a classic large ocean scenario, with the IOH split firmly into two cells and a good strong band of westerly winds to the south of them. This is perfect of you are half way across but the downside of this is that the eastern cell of the IOH often pushes south of Australia, giving a blocking high over the last section of the course before landfall. There is not much to be done about this except to study the forecast carefully to see where the next new wind is coming from (i.e. from the NW or SW generally) and positioning yourself closer to that expected direction by trying to edge further north or further south accordingly.

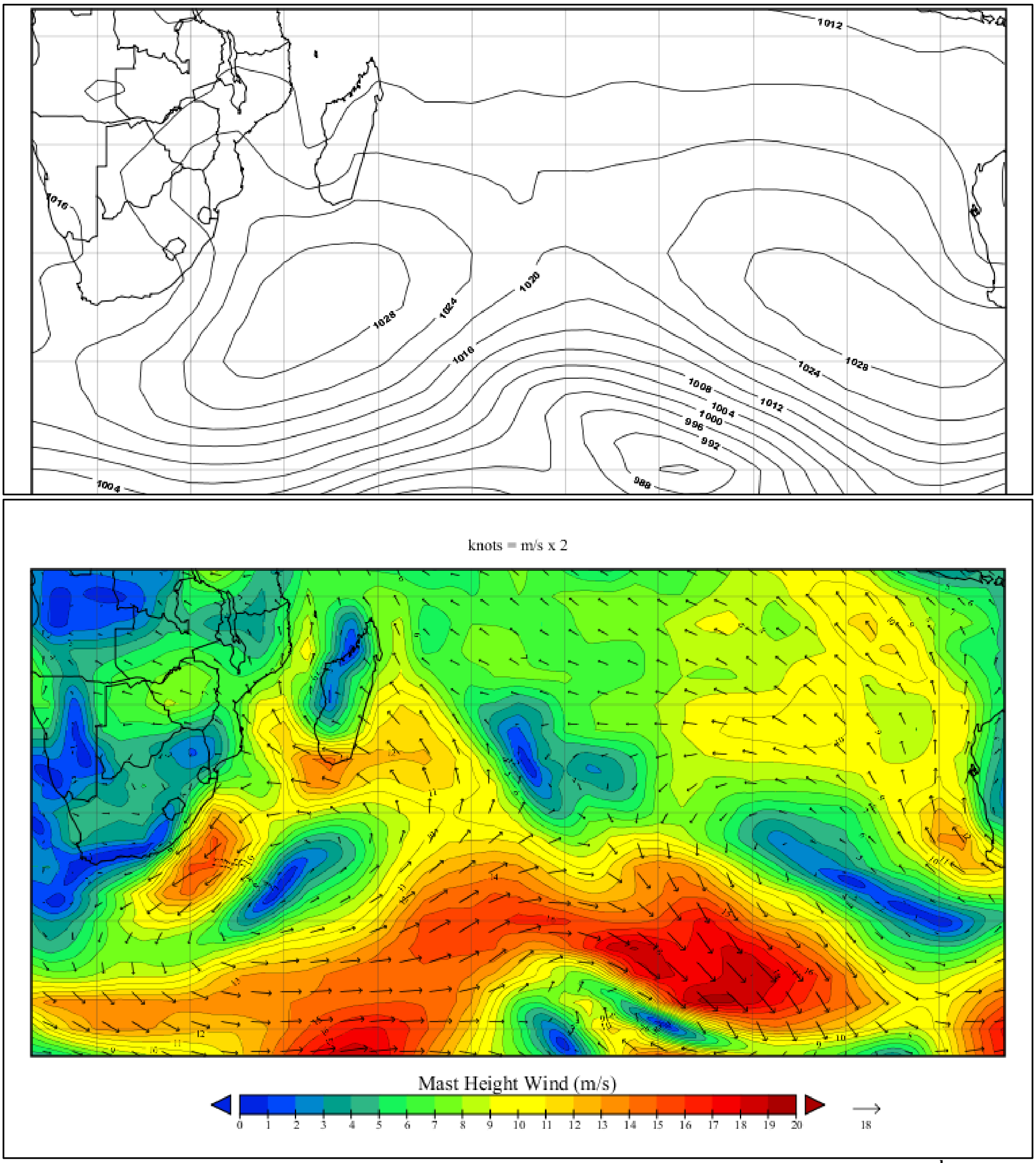


Fig 3.2.3: mean sea level pressure (top, hPa) and mast height wind (bottom, m/s) for October 23rd 2009 (5)

3.2.1. Southern Indian Ocean Fronts

These can be very strong, bringing with them a marked change in wind direction, heavy squalls and very confused sea states, illustrated by the front forecast to be from 60^{O}S, 82^{O}E to 50^{O}S, 107^{O}E on December 8th 2010 (*Figure 3.2.1.1).* The southern halves of the fronts are particularly energetic, due to the generally strong winds and the long fetch involved. Not shown here is the wave period, which can decrease from an average of about 10 to 12 seconds to less than half that – in other words the waves get twice as steep, as well as generally larger. The opposite problem occurs at the trailing edge, particularly if the front is trailed over a gap between two highs – this tends to make the lack of wind even worse.

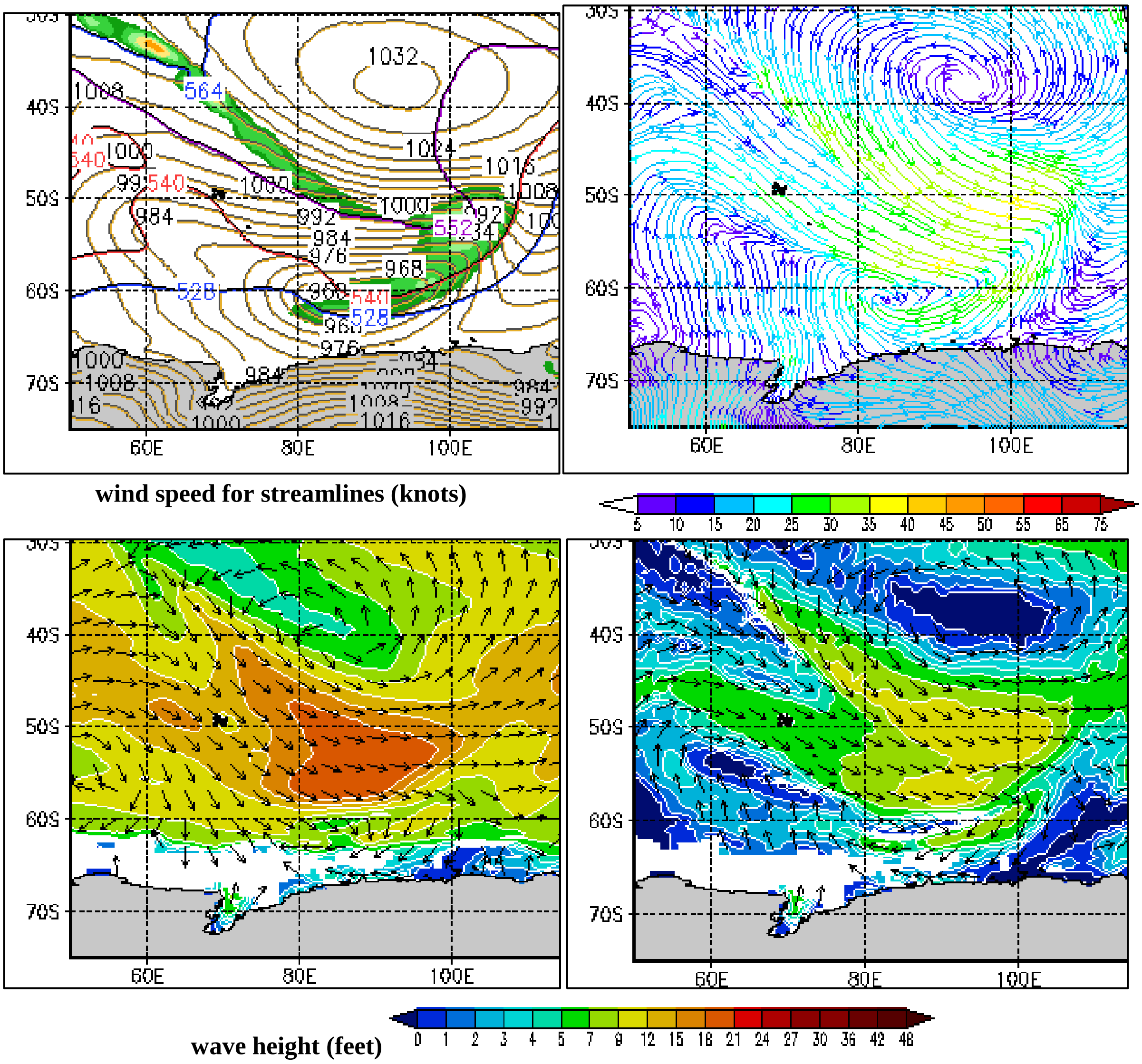


Figure 3.2.1.1: forecast for 1800 GMT December 8th 2010 showing (top left) surface pressure and precipitation (top right) surface wind speed and direction (bottom left) significant wave height and direction (bottom right) wind-driven wave height and direction (14)

3.3. Currents

3.3.1 Currents around the Aghulas Bank

The currents around the Aghulas bank originate from the westward movement of water across the northern side of the southern Indian Ocean high, which is channelled down the east coast of Madagascar where it meets the Mozambique current coming south between Mozambique and Madagascar. This forms the Aghulas current itself, which then flows south westwards along the Natal coast down to the Aghulas Bank (*Figure 3.3.3.1).* The current forms a gyre off the southern tip of this bank, turning back on itself and joining the east going Antarctic Circumpolar Current (ACC). This is shown for the mean from October 15th to 30th for 1993 to 2009 (*Figure 3.3.3.2)* and for a snapshot, a 5 day average centred on October 27th 2009 (*Figure 3.3.3.3).* One academically interesting but potentially frustrating local phenomenon is the throwing off of small enclosed gyres to the west past the southern tip of the Aghulas Bank (*Figure 3.3.3.4)*. These cannot be predicted in advance, only tracked once they have started, and give a little boost if you are on the western edge, a small hindrance if you're on the eastern edge. Small comfort if you can see another yacht getting the boost.

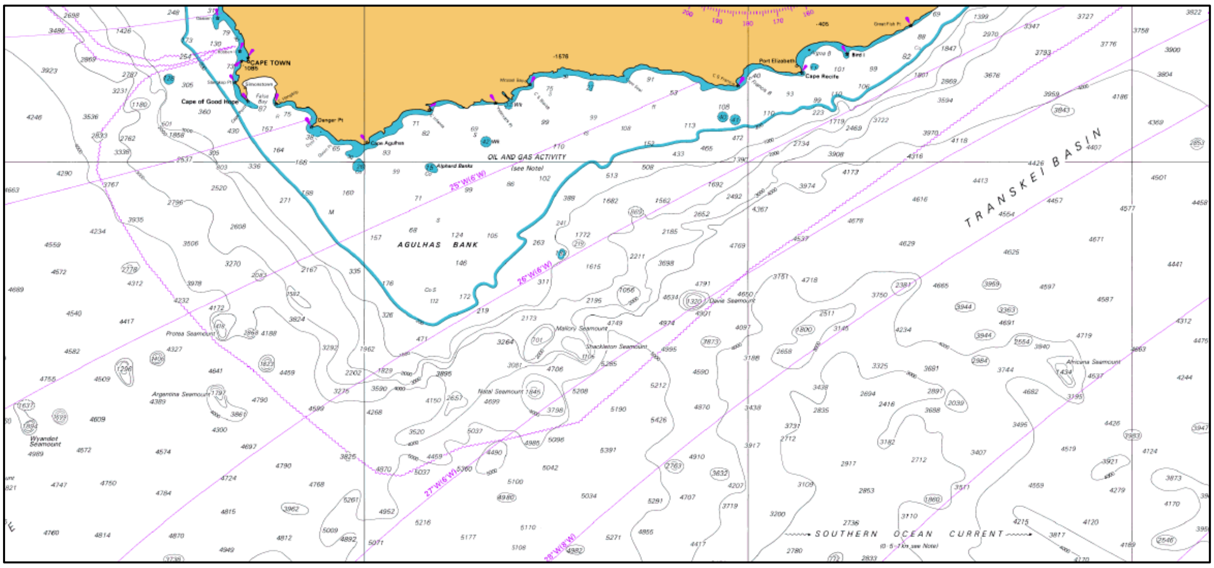


Fig 3.3.3.1: the Aghulas Bank (15)

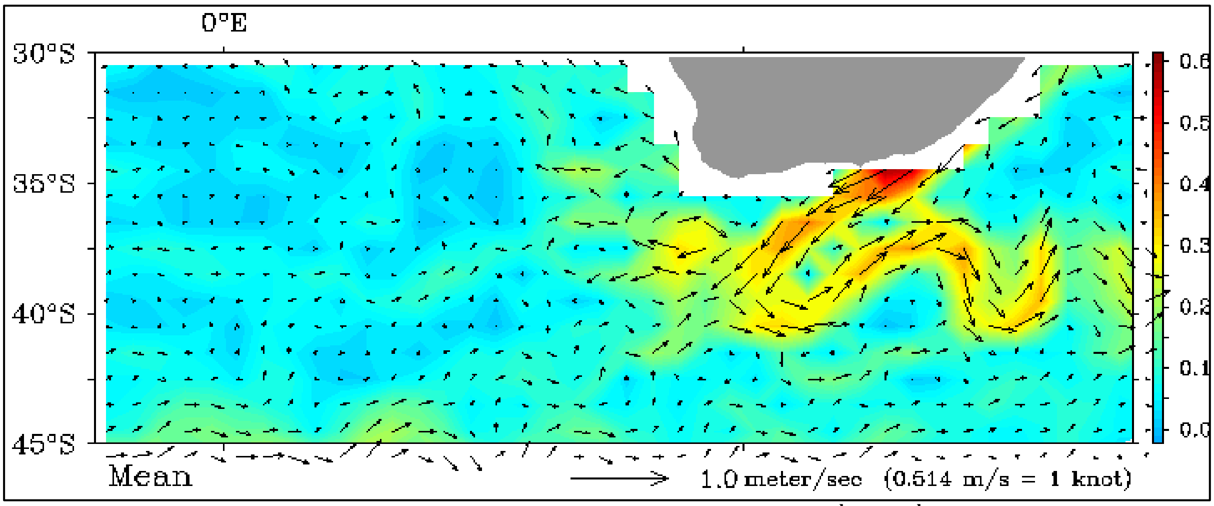


Fig 3.3.3.2: mean (unfiltered) surface current (m/s) for October 15th to 30th, 1993 to 2009 (10)

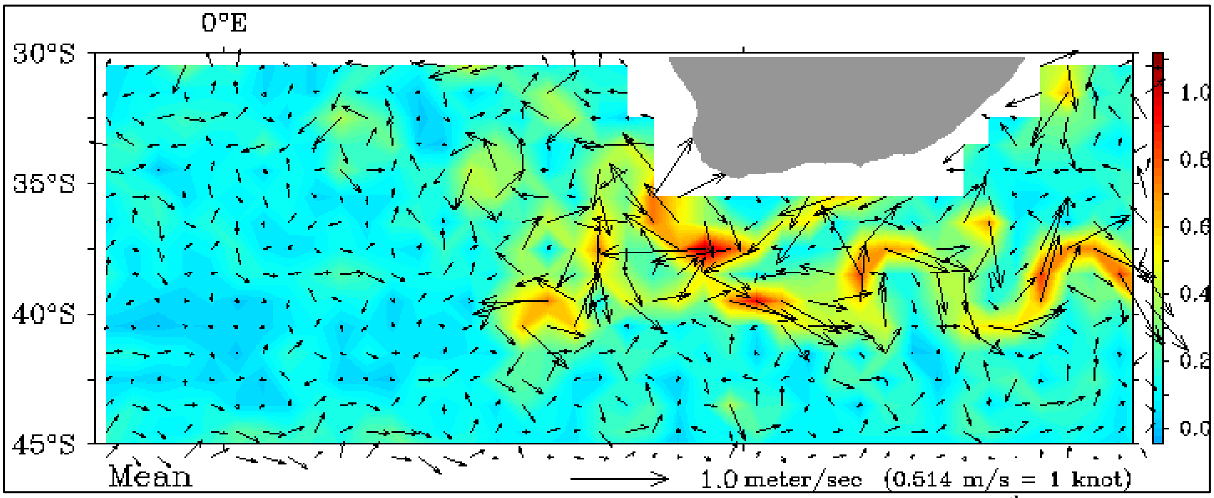


Fig 3.3.3.3: 5 day mean (unfiltered) of surface current (m/s) centred on October 27th 2009 (10)

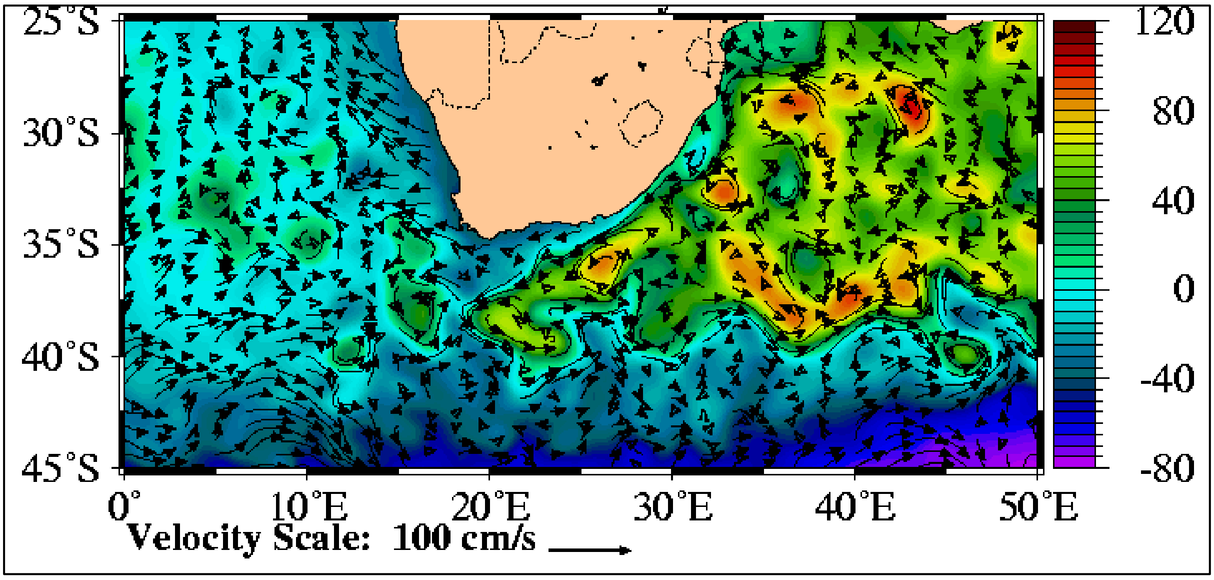


Fig 3.3.3.4: surface current (cm/s) over sea surface height, showing the green anticlockwise gyres moving to the west off the bottom of the Aghulas Bank, October 30th 2009 (12)

3.3.2 Currents in the Southern Indian Ocean

The significant one is the ACC, which can reach up to 3 or 4 knots in places. As this is primarily wind-driven, it tends to follow the average band of most consistent westerlies, as shown for October 15th to 25th and October 25th to November 15th, averaged from 1993 to 2009 (*Figures 3.3.2.1 and 3.3.2.2)* The most consistent current tends to move southwards the further east you go, becoming consistently south of 40°S E of 55°E. Note the significant stream north of the Kerguelens (48°S, 70°E) – due to the great change in depth in this region the sea surface temperature, never high, may be reduced further by the upwelling of deep Antarctic water, so increasing the chances of fog.

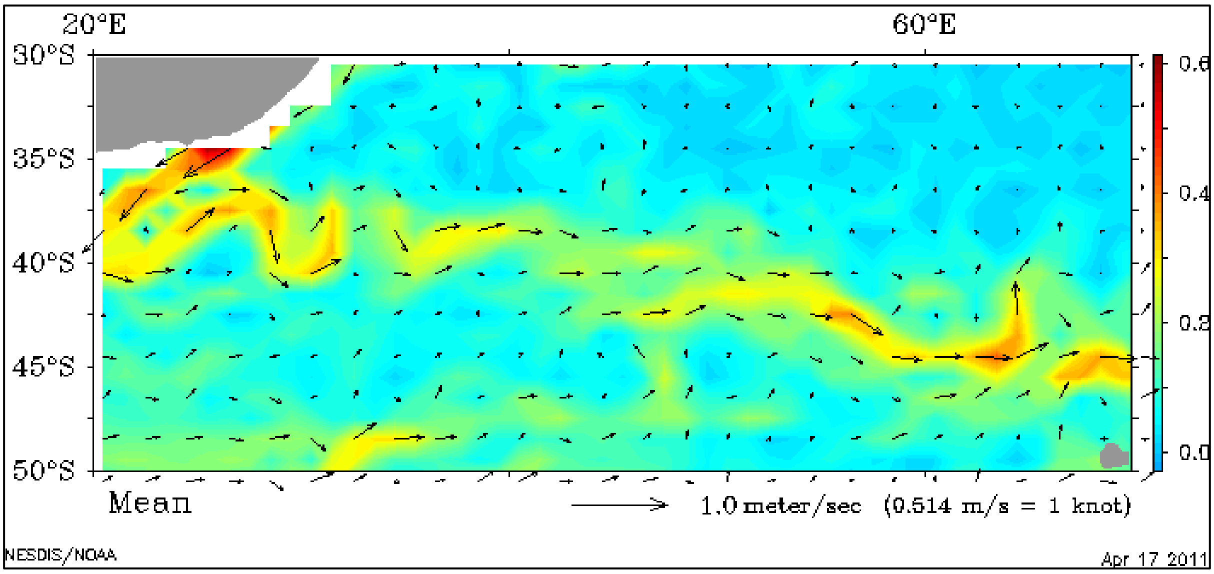


Fig 3.3.2.1: mean surface currents (m/s) for October 15th to 25th, 1993 to 2009 (10)

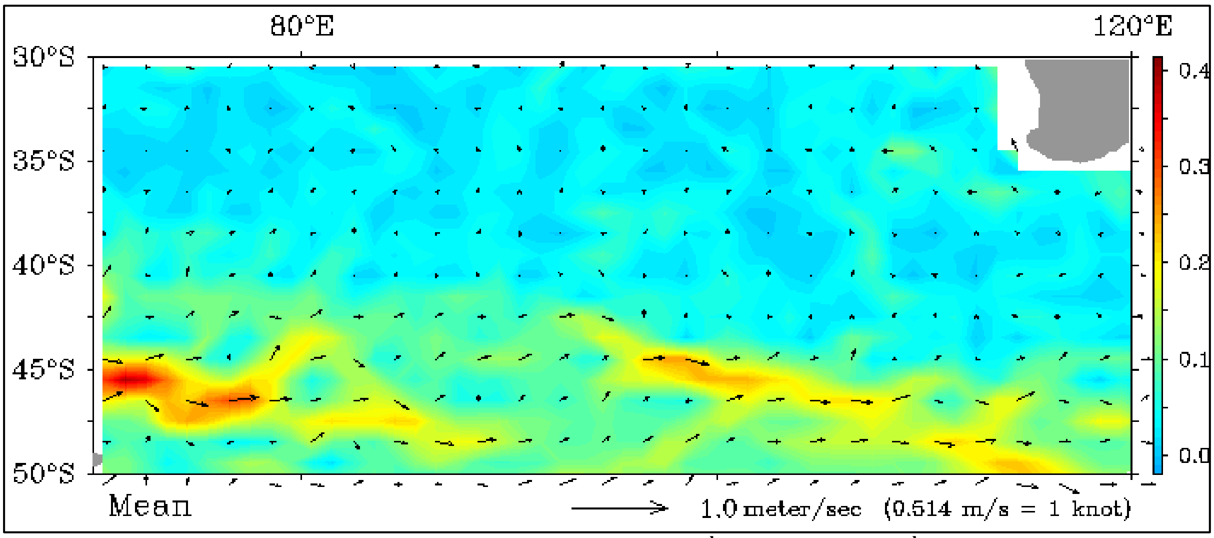


Fig 3.3.2.2: mean surface currents (m/s) for October 25th to November 15th, 1993 to 2009 (10)

4. Leg 4 –Western Australia to Wellington to Eastern Australia (mid November to December)

4.1. The Route

Assuming a Geraldton start Race 5 to Wellington is just under 3300 miles, with two main ocean legs and a significant amount of coastal work (*Figure 4.1.1).* Race 6 from Wellington back to Gold Coast is one single approximately 1300 mile ocean leg (*Figure 4.1.2).*

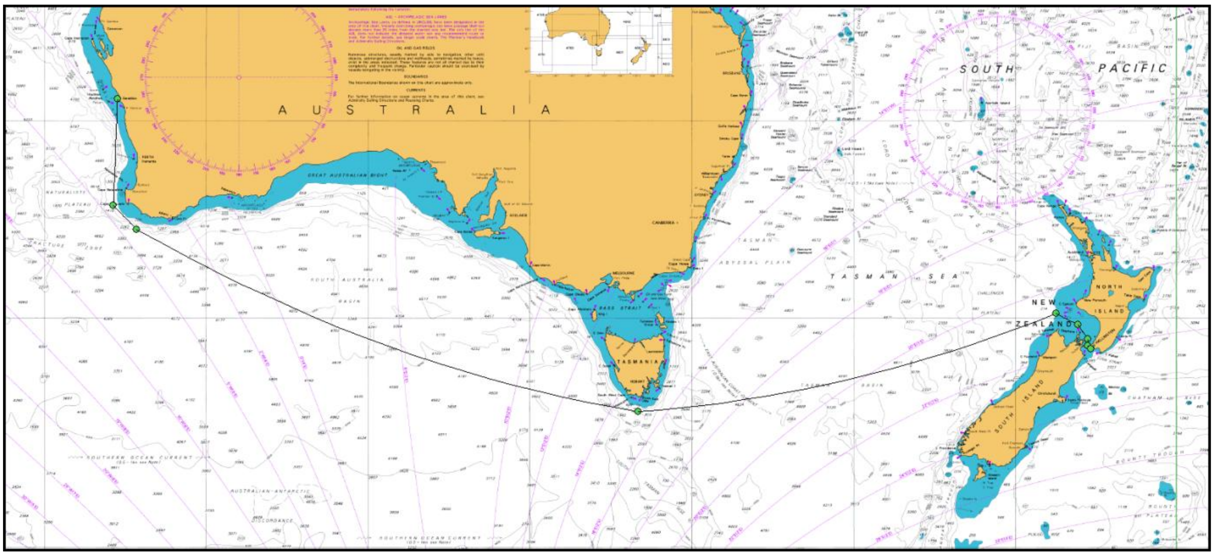


Fig 4.1.1: Race 5 from Geraldton to Wellington (16)

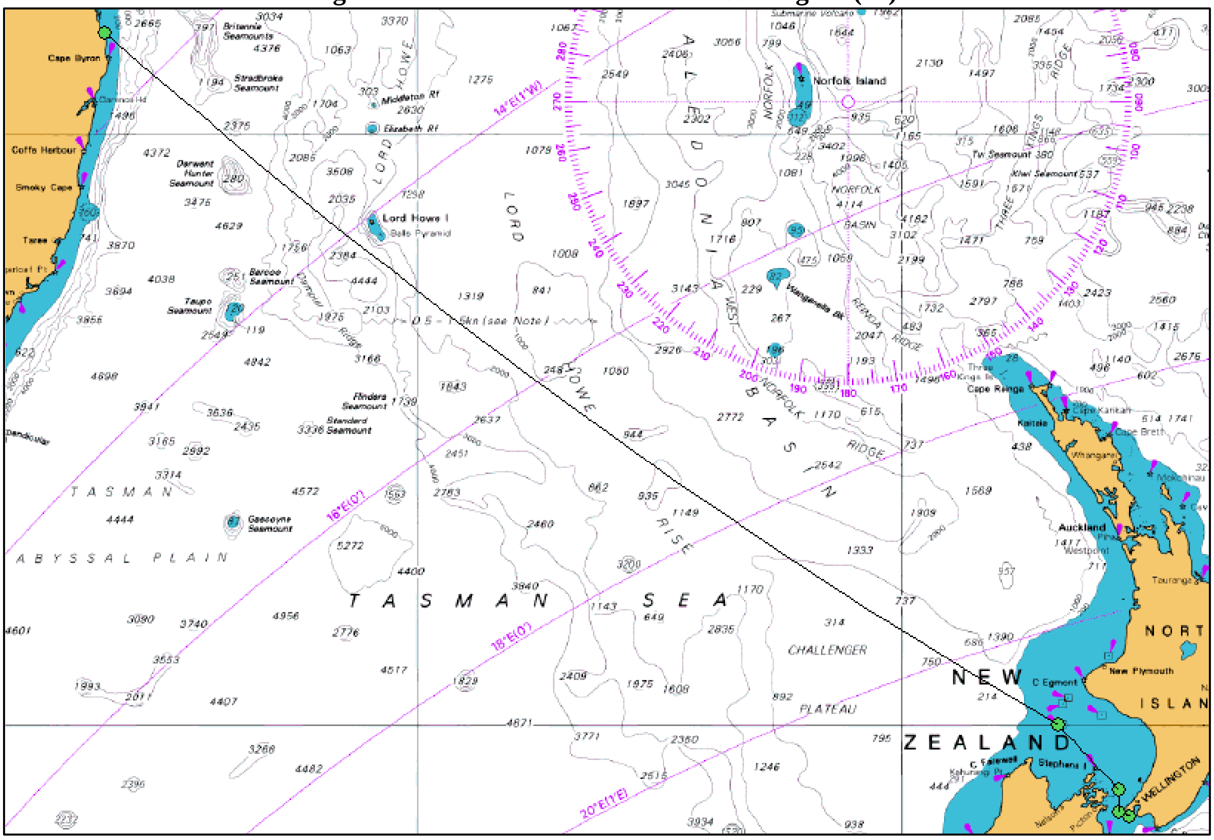


Fig 4.1.2: Race 6 from Wellington to East Australia (16)

4.2. The Weather

4.2.1. Cape Leeuwin to Tasmania

The routing chart for November shows winds prevailing from NW to SW from Cape Leeuwin to Tasmania (*Figure 4.2.1.1)*. Around Cape Leeuwin itself the winds in the southern hemisphere summer are predominantly SE, especially in the afternoon (17).

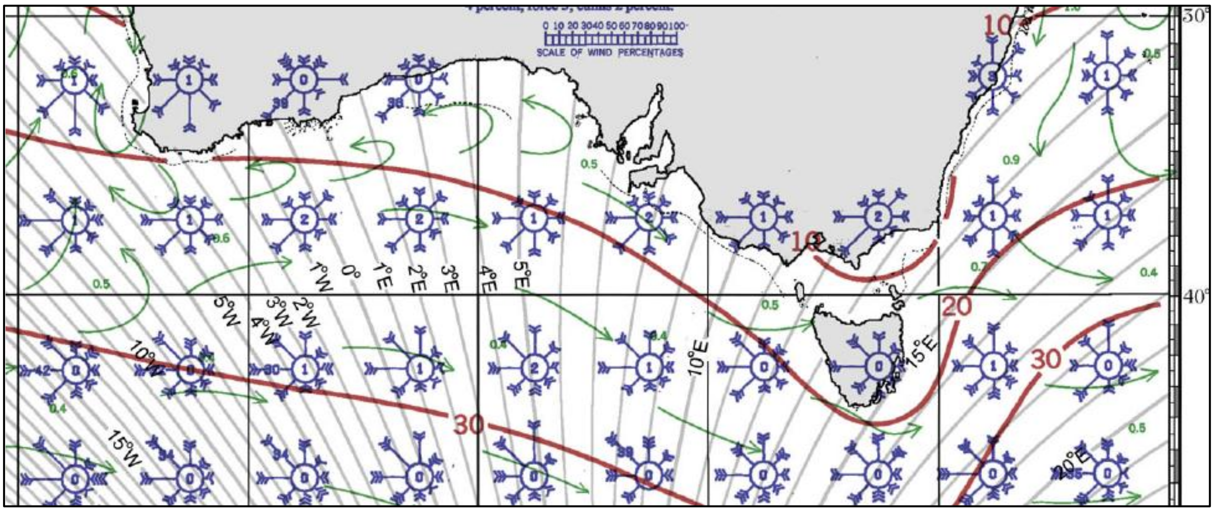


Fig 4.2.1.1: routing chart extract for November (4)

Looking at the average mast height wind for November for 1948 to 2010 (*Figure 4.2.1.2)* adds some more detail to this, and highlights an area of average light winds centred on 36^{O}S, 125^{O}E.

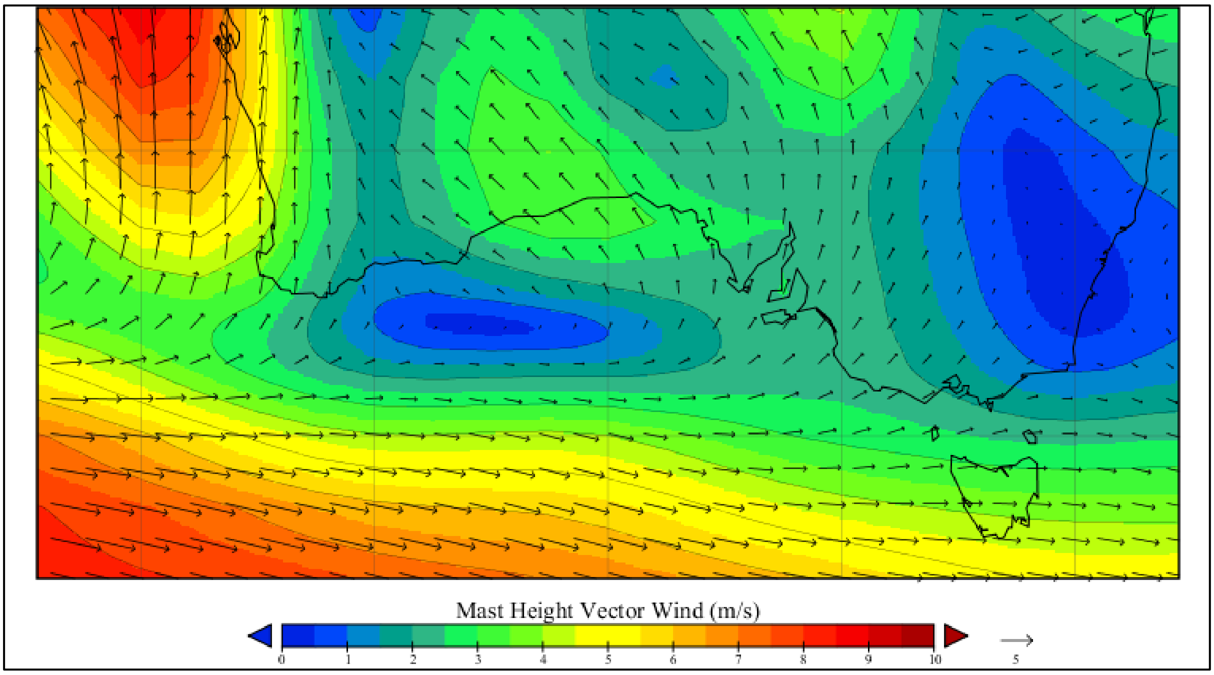


Fig 4.2.1.2: mast head height wind (m/s) averaged for November, 1948 to 2009 (5)

It is the procession of systems that decides the day to day weather, though, so it is useful to look at a typical November progression.

November 22nd 2009 (*Figure 4.2.1.3)*: the eastern cell of the IOH has been pushed over Cape Leeuwin, giving light S winds down to it. The Antarctic depressions to the south are giving strong W winds S of the high.

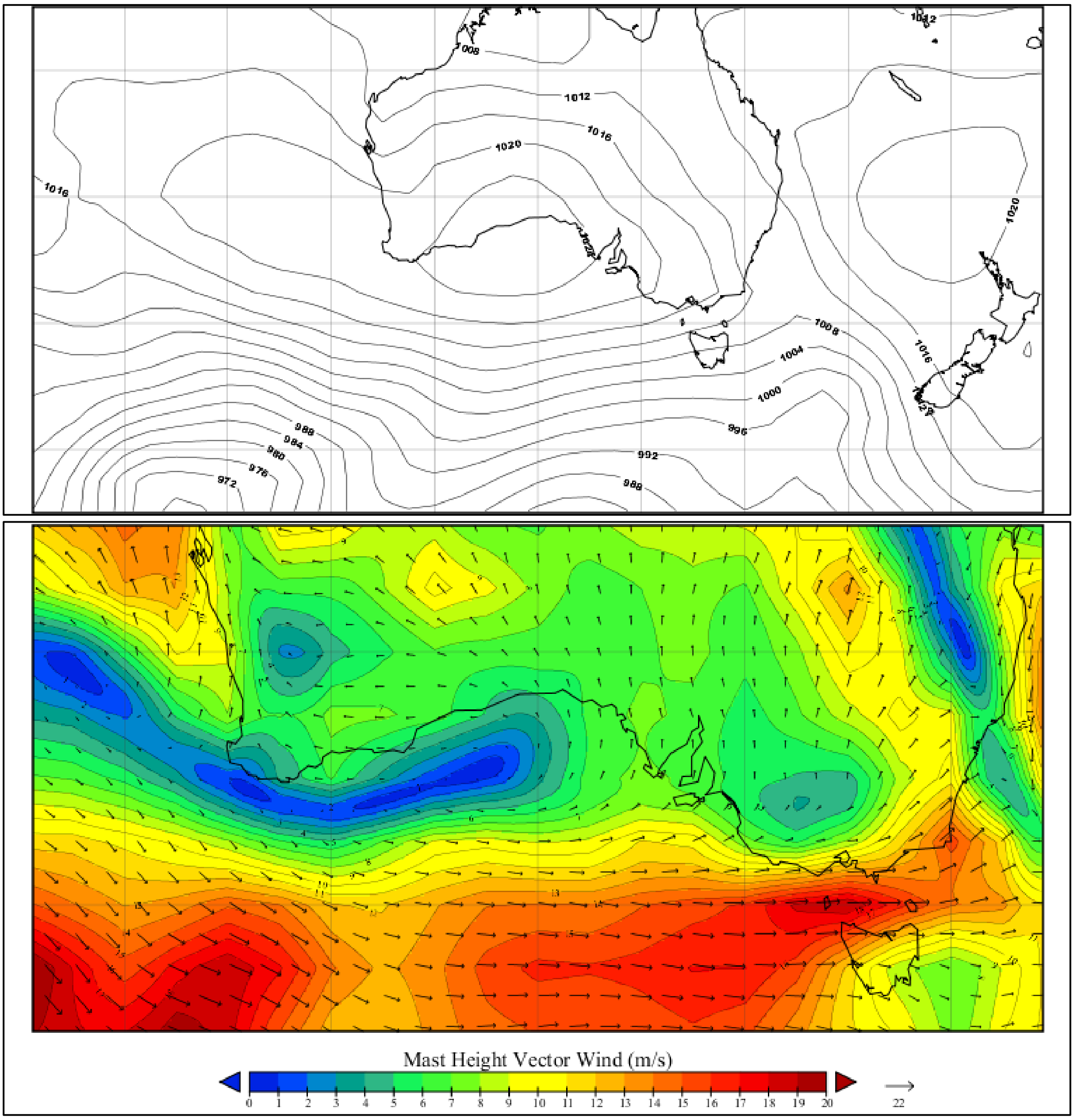


Fig 4.2.1.3: mean sea level pressure (top, hPa) and mast height vector wind (bottom, m/s) for November 22nd 2009 (5)

November 25th 2009 (*Figure 4.2.1.4)*: the high pressure cell has been squeezed along the S coast of Australia into the Tasman Sea, and a long front is trailing between this cell and the next IOH cell in the west. This looks as if it is starting to rotate to form a secondary low. The winds behind this front are gale force, 40 knots plus (1 m/s = 2 knots) from the S, and would make passing close inshore to Cape Leeuwin a remarkably unseamanlike thing to do. Also the swell S of Australia is likely to be from the W or SW, and strong crosswinds can cause very confused seas.

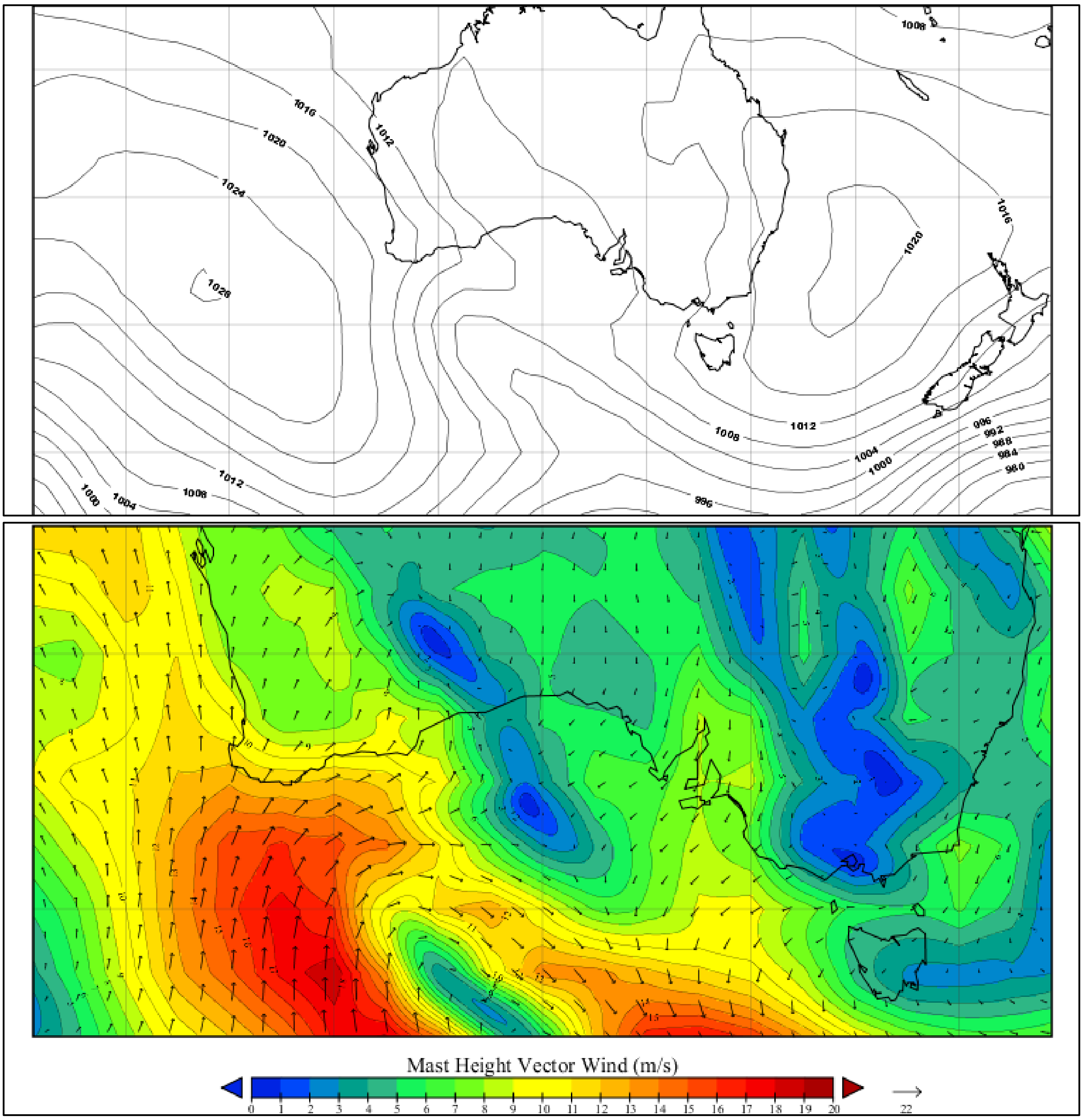


Fig 4.2.1.4: mean sea level pressure (top, hPa) and mast height vector wind (bottom, m/s) for November 25th 2009 (5)

November 28th 2009 (*Figure 4.2.1.5)*: a secondary low has developed just NW of Tasmania now and the approaching IOH cell appears to be splitting just SW of Cape Leeuwin.

This third snapshot illustrates the importance of monitoring the position of the low and high pressures and the fronts between them, as that will allow you to try and position yourself closer to the oncoming wind. On this relatively short leg there is not much scope for tactical moves, but by being 15 miles further north or south you can pick up the new wind a couple of hours earlier, and this will translate into small gains each time.

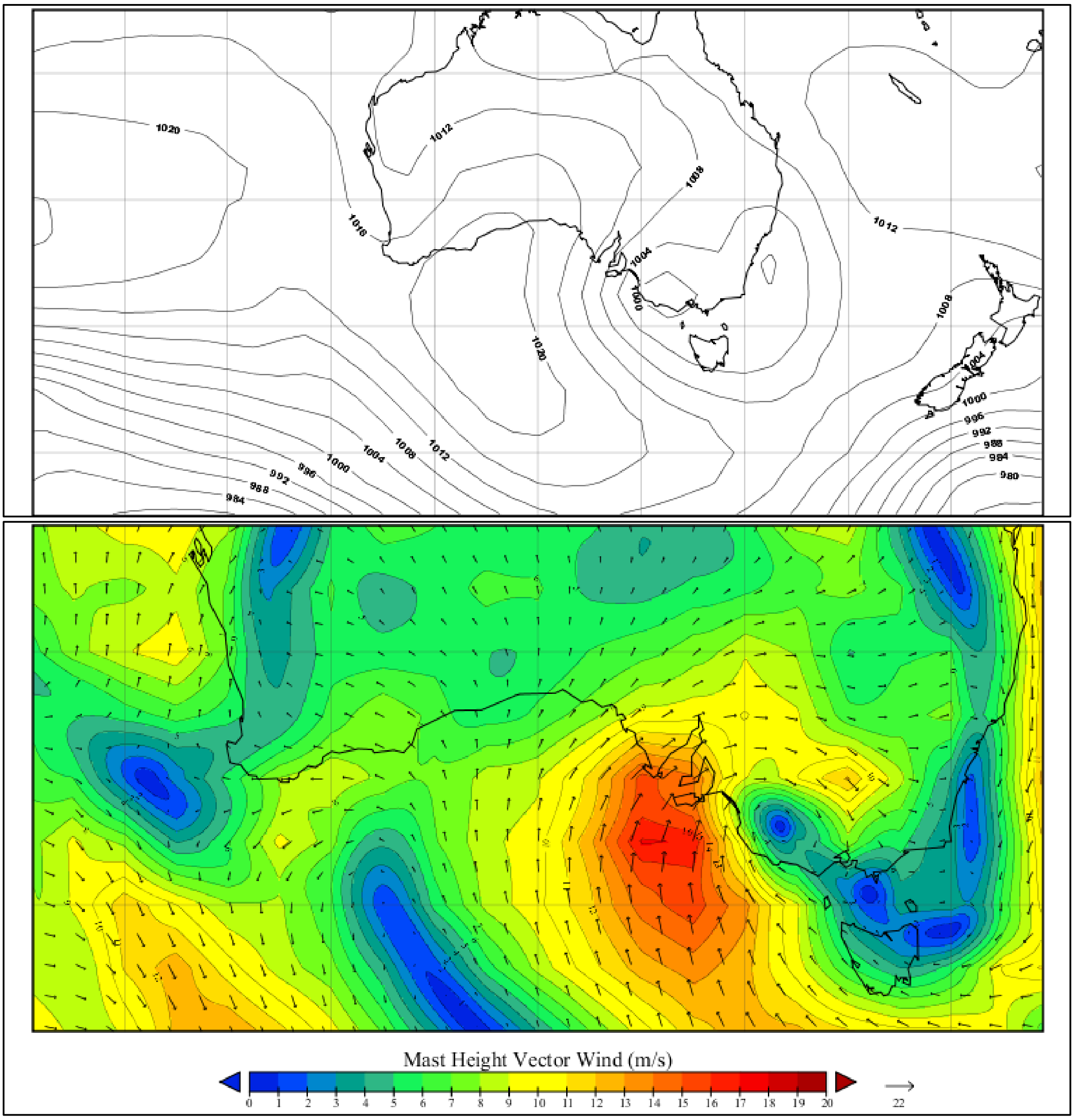


Fig 4.2.1.5: mean sea level pressure (top, hPa) and mast height vector wind (bottom, m/s) for November 28th 2009 (5)

4.2.2. Tasmania to Wellington and then to Gold Coast

Geographically these two legs are not that far apart, meteorologically they are. The routing chart for December (*Figure 4.2.2.1)* shows mostly W winds of some description from Tasmania to the Cook Strait, and then north of that it changes to more from the E, which is rather convenient. The average mast height winds for December, 1948 to 2010 (*Figure 4.2.2.2)* agree with this, showing a band of changeable winds between the two section.

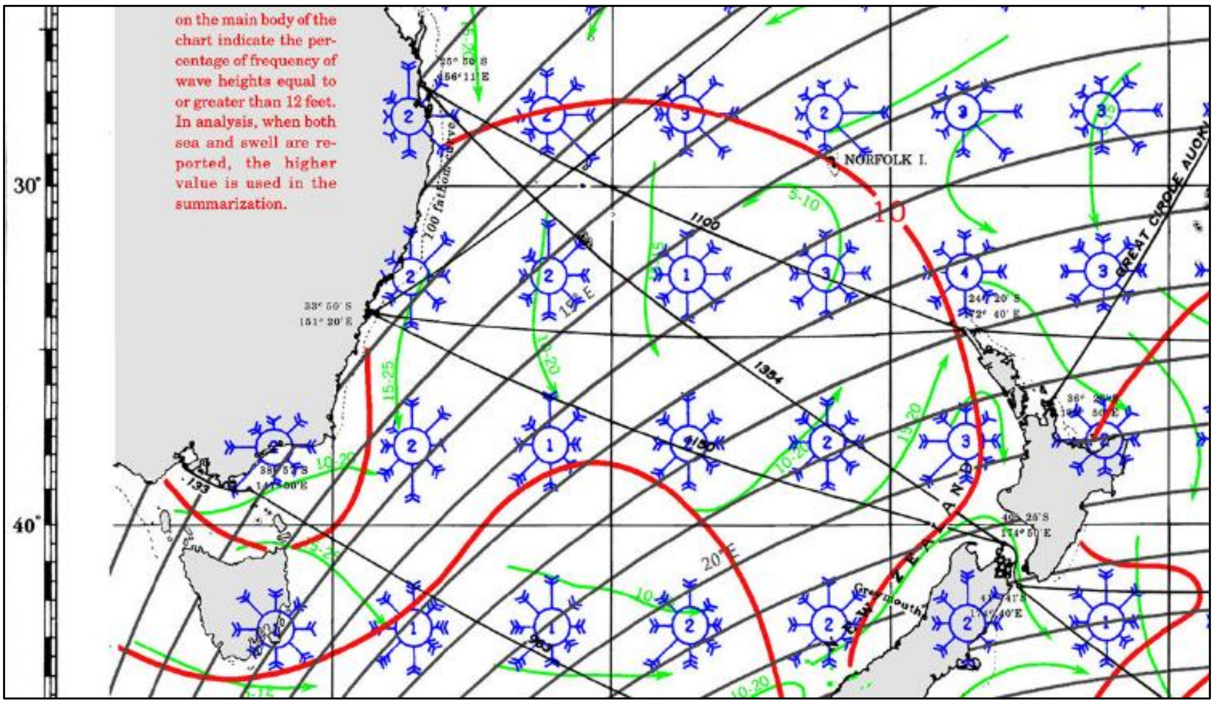


Fig 4.2.2.1: routing chart extract for December (4)

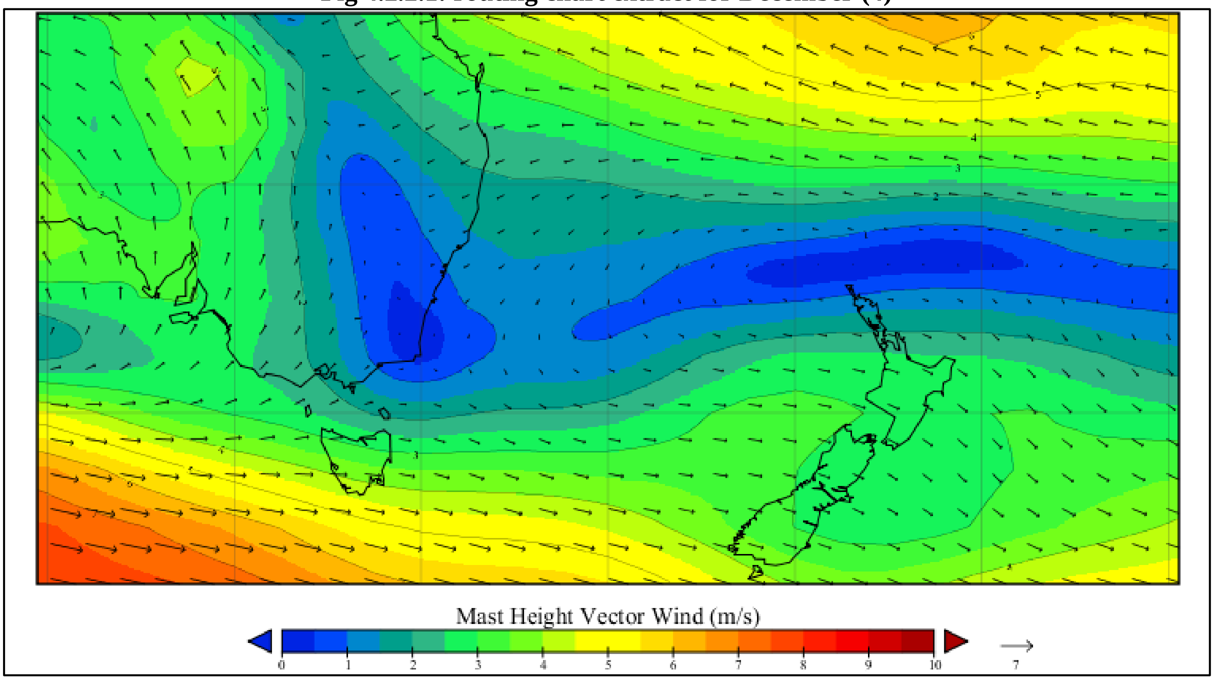


Fig 4.2.2.2: mean mast height winds (m/s) for December, 1948 to 2010 (5)

The average conditions are all very well, but again let’s look at a specific set of actual conditions. These basically add up to no particular prevailing direction in the northern half of the Tasman Sea.

December 8th 2009 (*Figure 4.2.2.3)*: the western cell of the Pacific Ocean High (POH) is butting up against the low generated by the hot Australian continent, giving strong northerlies down the E Australian coast. S of this a front coming up from an Antarctic low is dragging across the S of the Tasman Sea, bringing NW backing W winds.

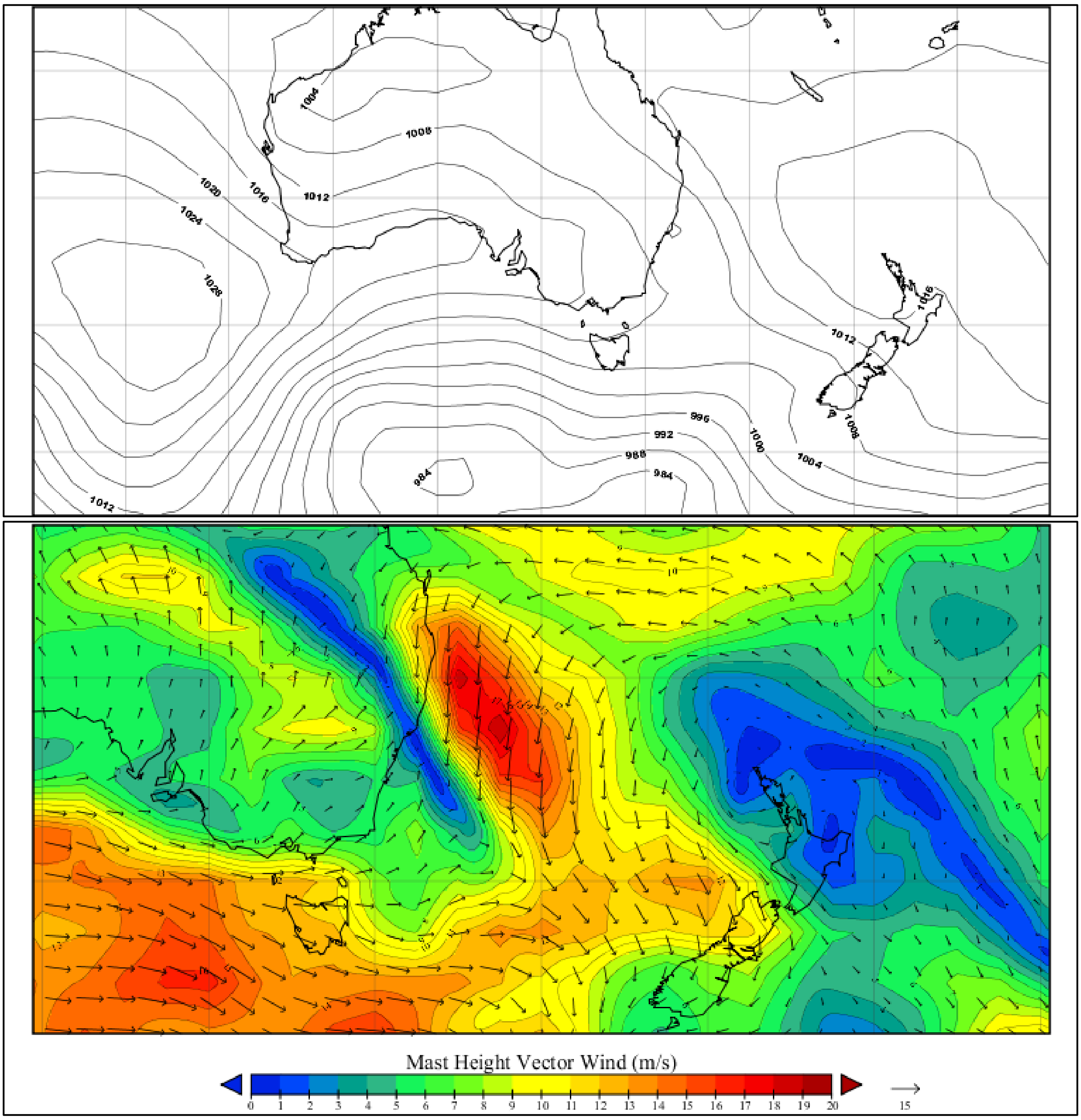


Fig 4.2.2.3: mean sea level pressure (top, hPa) and mast height vector wind (bottom, m/s) for December 8th 2009 (5)

December 12th 2009 (*Figure 4.2.2.4)*: the low has moved eastwards and the interaction between the POH and the Australian low has decreased. This gives W across the Tasman Sea into Wellington, but also either W or light and variable for the next leg to Gold Coast – which effectively turns that into the southern hemisphere equivalent of going against the Trades and then across the Horse Latitudes.

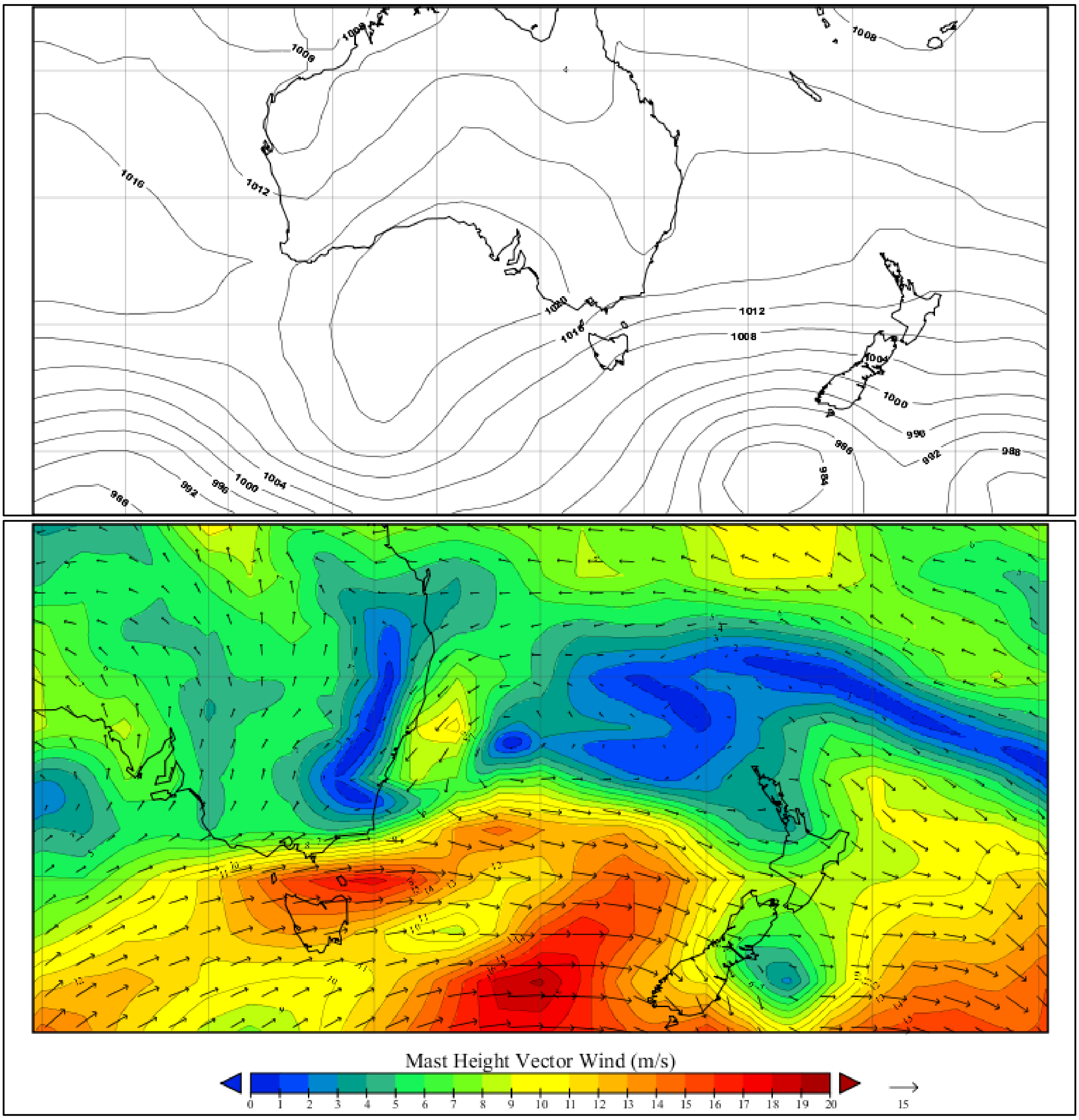


Fig 4.2.2.4: mean sea level pressure (top, hPa) and mast height vector wind (bottom, m/s) for December 12th 2009 (5)

December 14th 2009 (*Figure 4.2.2.5)*: the previously depressing notion of a beat followed by a drift to Australia is alleviated by this synoptic situation, where the high pressure cell squeezed along the S coast of Australia is pushed into the Tasman Sea causing an anticyclonic and therefore largely favourable circulation to head north and west from Wellington. Being driven by an anticyclone this will tend to move quite slowly over the Tasman Sea, taking two or three days to disperse.

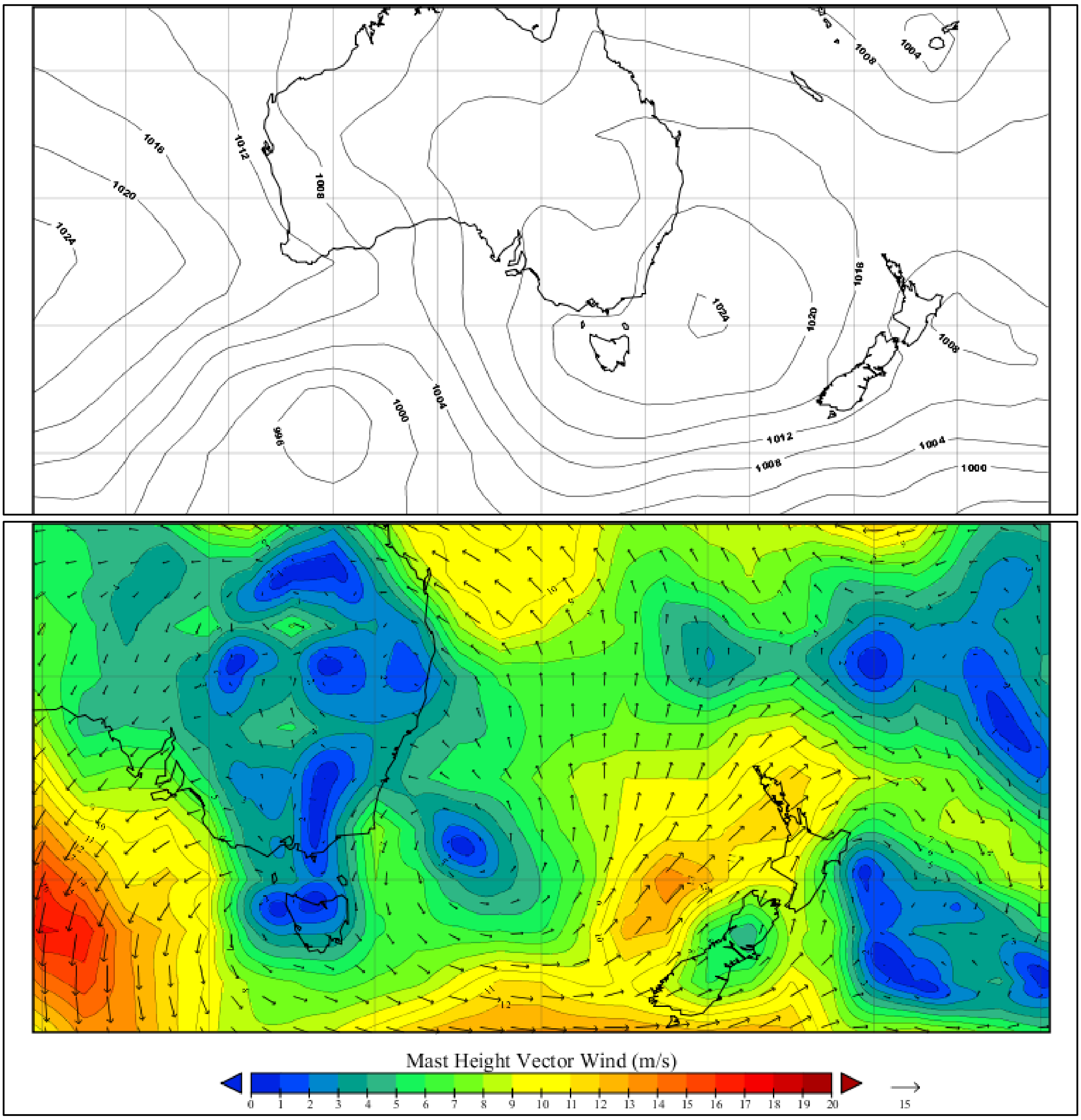


Fig 4.2.2.5: mean sea level pressure (top, hPa) and mast height vector wind (bottom, m/s) for December 14th 2009 (5)

4.3. Currents

The routing chart (*Figure 4.2.1.1)* shows a general E going trend S of Australia, with local eddies in coastal parts. There is no major current advantage is this section, confirmed by the mean surface current for November 15th to 25th, 1993 to 2009 (*Figure 4.3.1)* which shows the general E trend. Close to the S coast of Tasmania there is a more significant W going eddy.

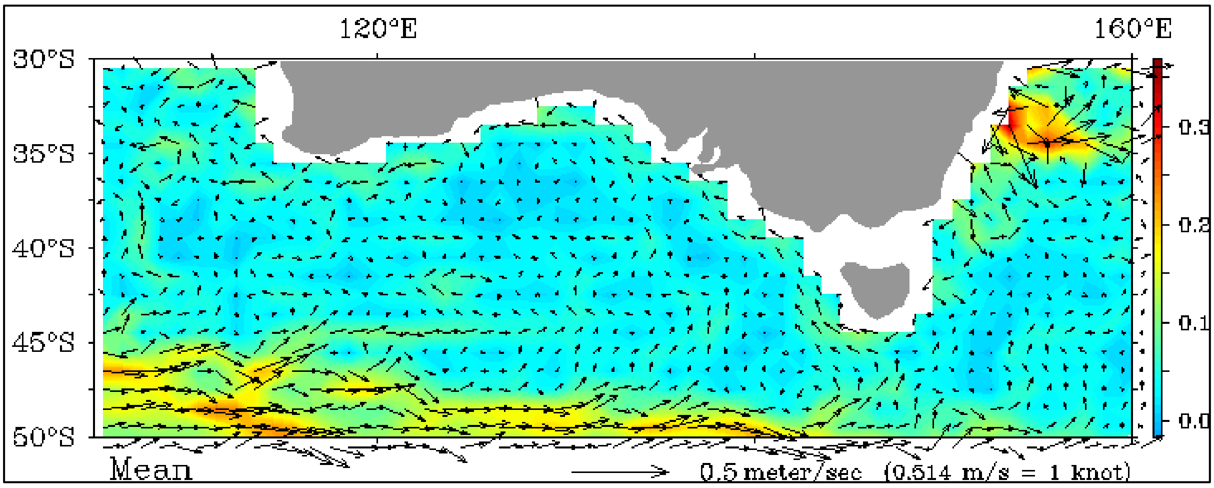


Fig 4.3.1: mean surface currents (m/s) for November 15th to 25th, 1993 to 2009 (10)

In the S Tasman Sea there is no significant current, just a general E or NE going circulation. From Wellington to Gold Coast there is a stream of E going current at about 33^{O}S, and along the Australian coast the East Australian Current flows strongly S along the 100 fathom contour *(Figure 4.3.2).*

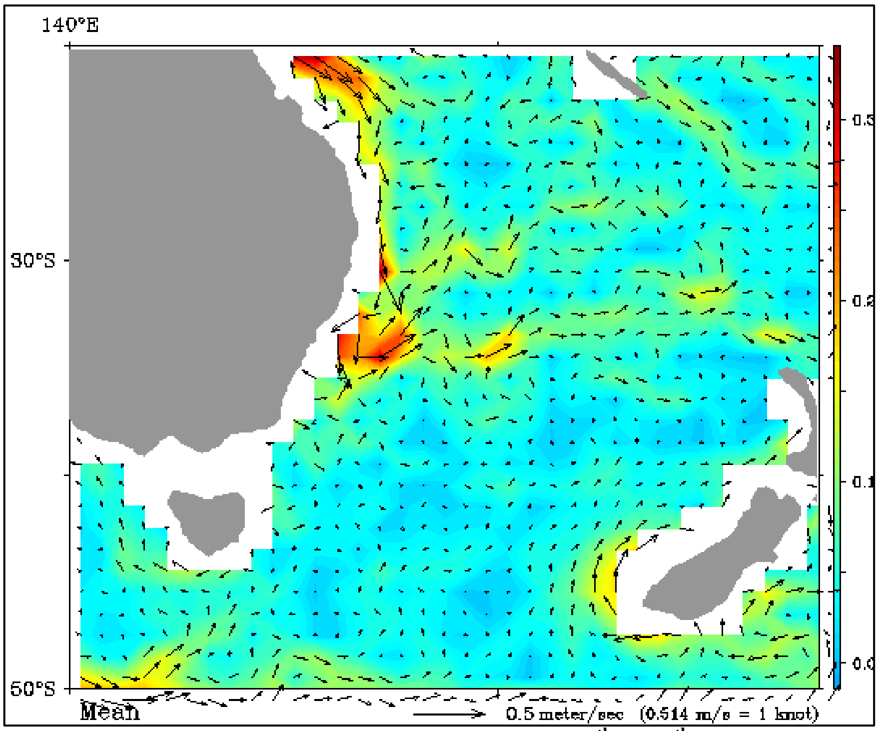


Fig 4.3.2: mean surface currents (m/s) for December 5th to 25th, 1993 to 2009 (10)

5. Leg 5 – Gold Coast to Singapore to Qingdao (early January to end of February)

This leg is made up of two very different races, which will be discussed separately.

5.1. Gold Coast to Singapore

The route for this is not yet decided at time of writing, so the following is a suggested route only, with conditions described for the region.

5.1.1. A Suggested Route from Gold Coast to Singapore

This is a navigationally awkward race, balancing the ITCZ, the usual Tropical Cyclone tracks, badly charted and shallow passages and piracy. A suggested route is as shown (*Figure 5.1.1.1)*, and is about 4300 miles long. This route is the best for probable wind, speed across the likely TC track area and directness across the ITCZ, and there are reasonably deep passages into, across and out of the Celebes and Sulu Seas. These are the passage S of the Sarangani Islands (5^{O} N, 125^{O} 30'E), the Basilan Strait (6^{O} 48'N, 122^{O}E) and the Balabac Strait (7^{O} 40'N, 117^{O}E). The only factor not taken into account is the risk of piracy.

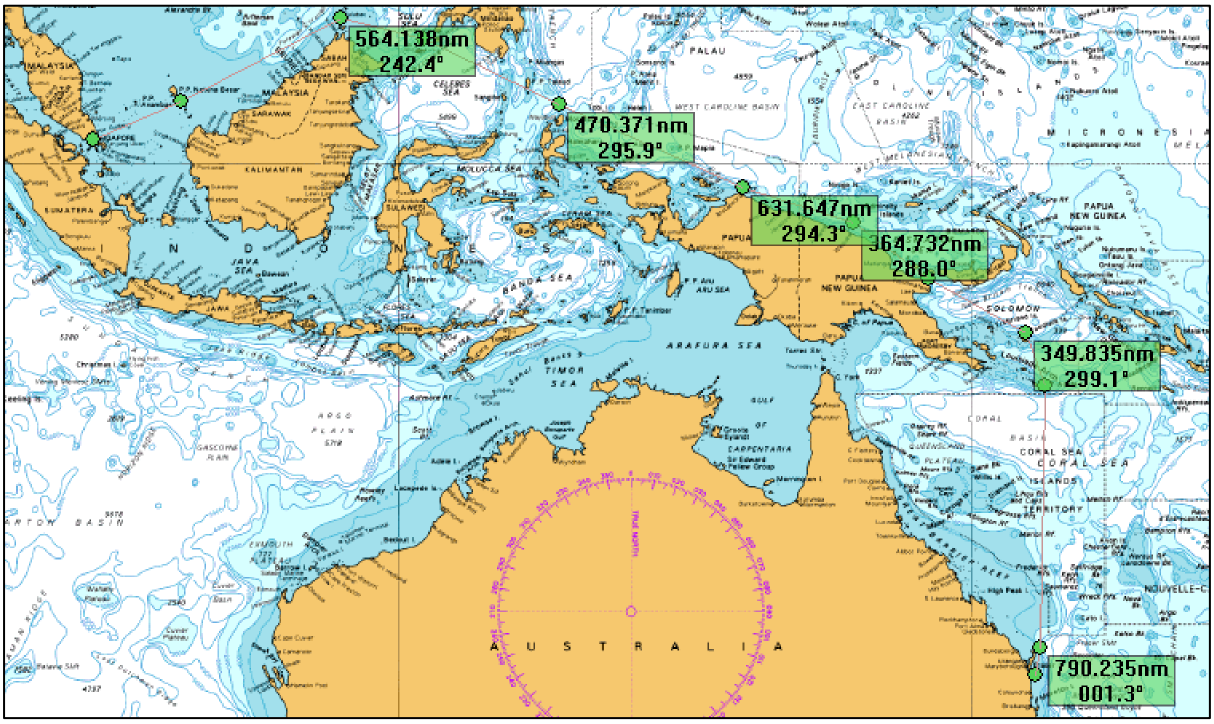


Fig 5.1.1.1: suggested route from Gold Coast to Singapore (13)

5.1.2. The Weather

Here again you'll find the ITCZ, and with this the belt of tropical cyclones (TC's) that run along the north coast of Australia. This is greatly affected by the state of El Nino or La Nina (*Section A.4)* – 2011/2012 is currently forecast as being a neutral year. 2010/2011 has been a strong La Nina event, with increased SST's in the W Pacific around the "maritime continent" of N Australia, Papua New Guinea, Indonesia and the Philippines. This causes increased convection and therefore more TC's (*Figure 5.1.2.1)*, e.g. cyclone Yasi in Queensland. In a neutral year the SST and therefore convection is lower, which reduces the expected number of TC's by about 40% (*Figure 5.1.2.2)*.

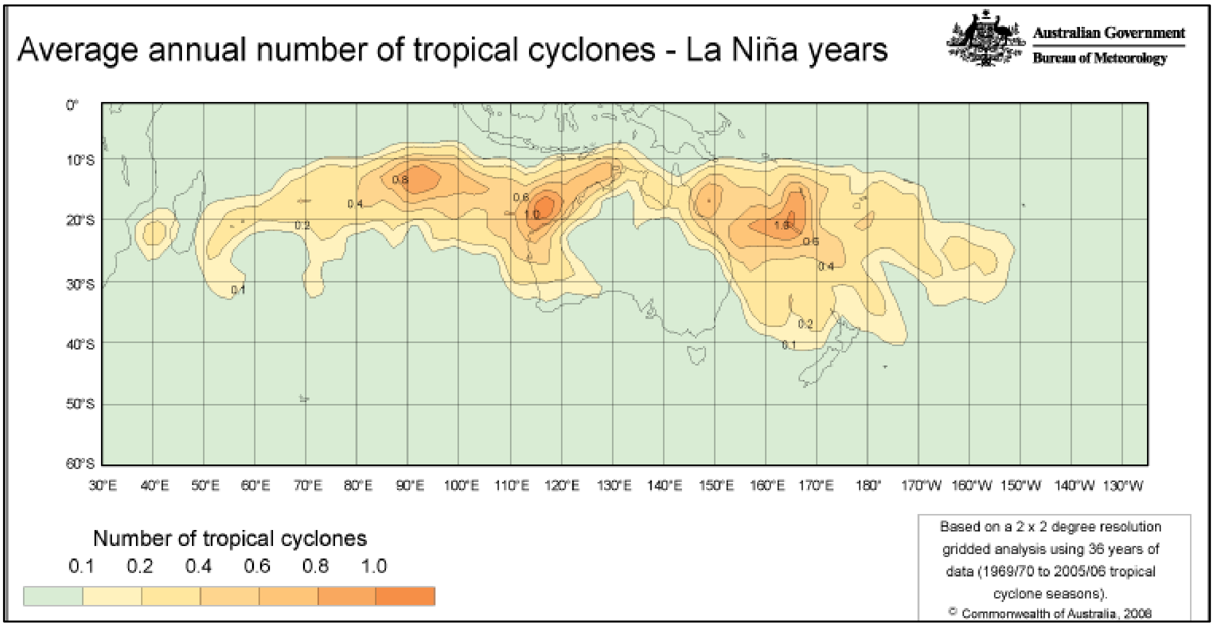


Fig 5.1.2.1: TC distribution in La Nina years (18)

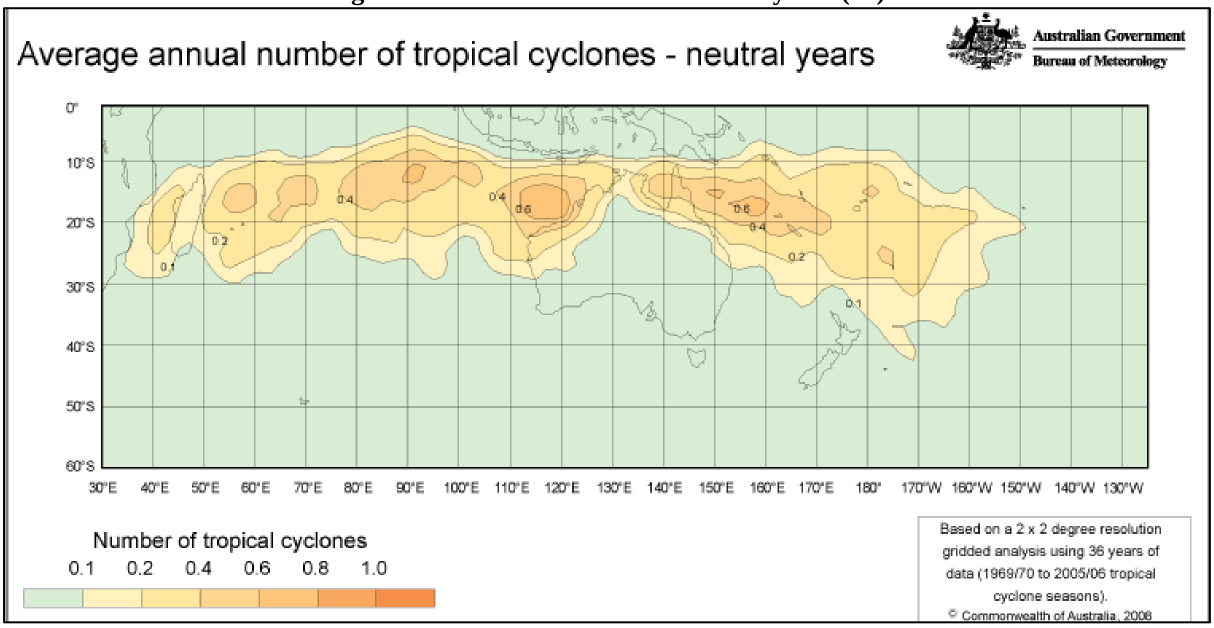


Fig 5.1.2.2: TC distribution in neutral years (18)

This averaged data is just that, and cannot predict an individual TC. They are, however, well forecast and the Australian Bureau of Meteorology (18) gives excellent data and charts for these. The TC tracks very rarely go further north than 10^{O}S (*Figure 5.1.2.3).*

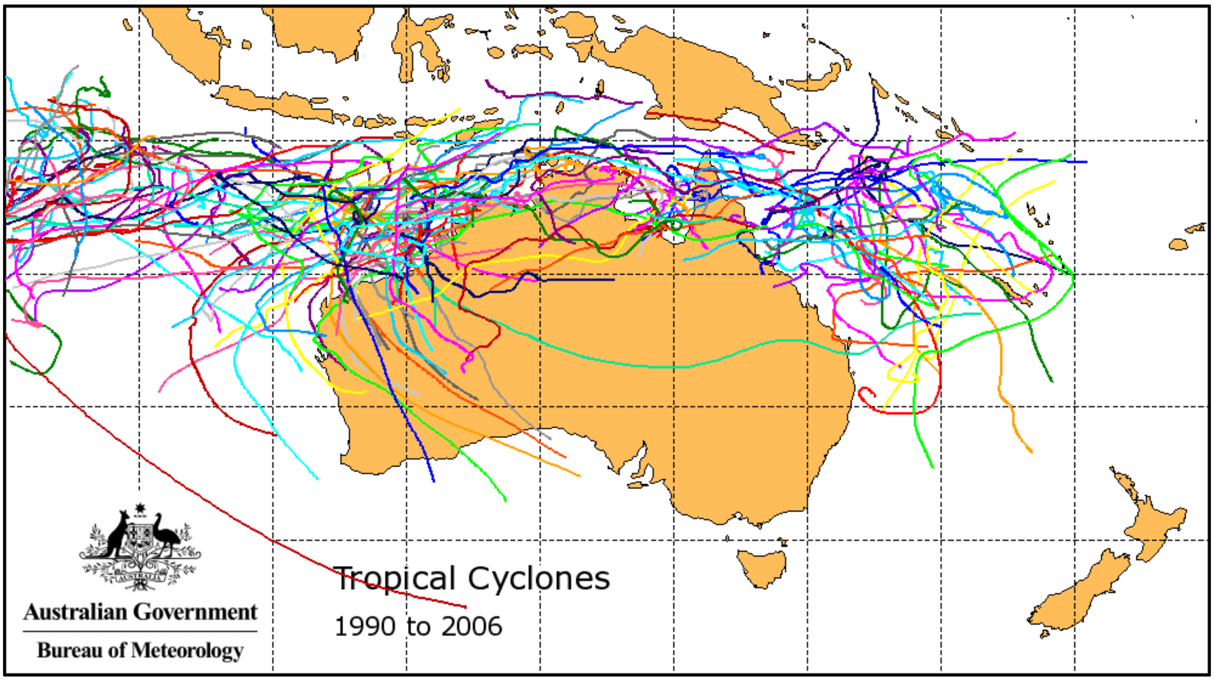


Fig 5.1.2.3: TC tracks for 1990 to 2006 (18)

The ITCZ is usually centred at about 10^{O} to 12^{O}S, and while the winds to the south are the expected SE Trades, those on the northern side are often NW (*Figure 5.1.2.4).* This is due to the NE Trades crossing the equator and then being turned leftwards by the Coriolis Effect south of the Equator.

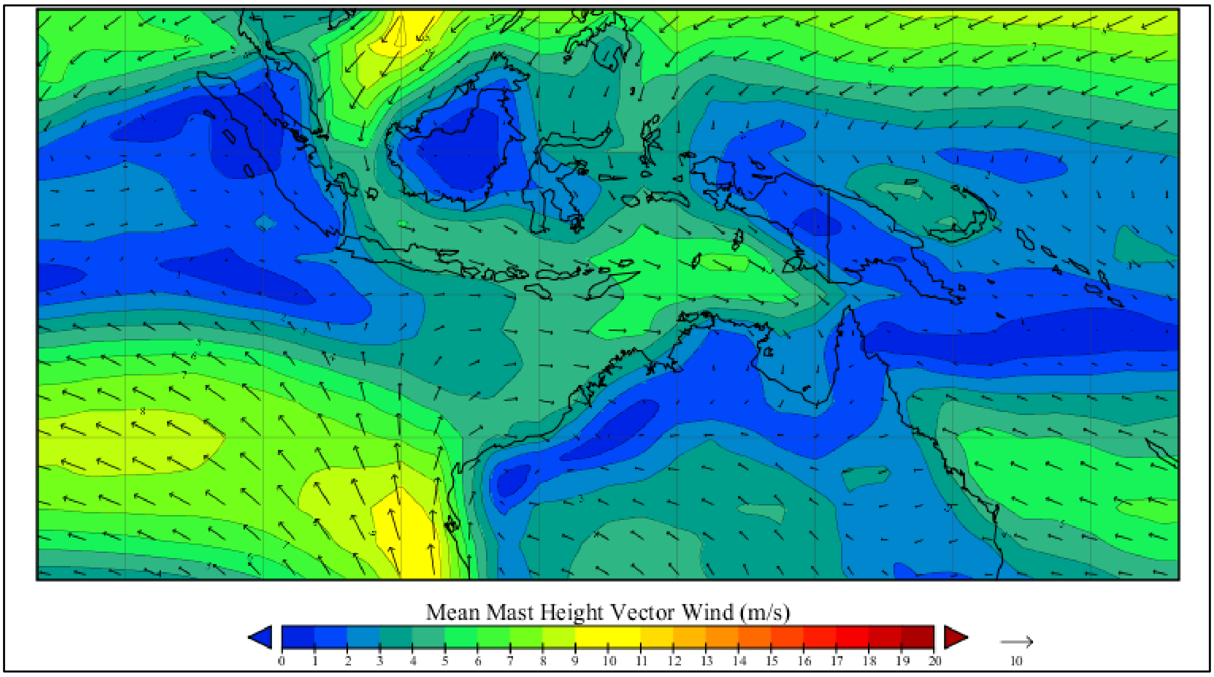


Fig 5.1.2.4: mean mast height vector winds for January, 1948 to 2011 (5)

So, to summarise the expected winds will be E or SE Trades up the E coast of Australia, the ITCZ and possible TC tracks at about $12^{O}S$ (± a couple) followed by NW to N to NE winds going N to Singapore. There will be much squall activity (*Section A.1).*

5.1.3. Currents

These are generally wind driven, and are not particularly strong except along the north coast of Papua New Guinea, as shown by the routing chart (*Figure 5.1.3.1)* and the average surface current for 5th to 25th January, 1993 to 2009 (*Figure 5.1.3.2).*

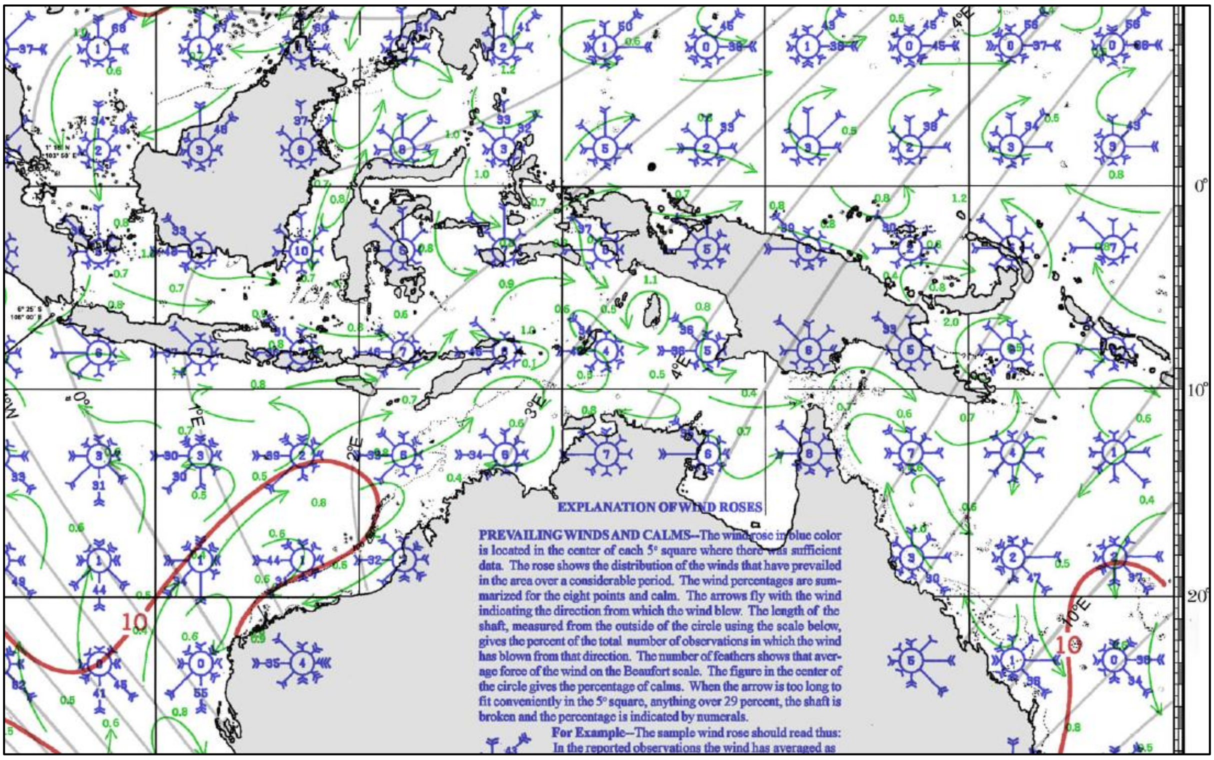


Fig 5.1.3.1: routing chart for January (4)

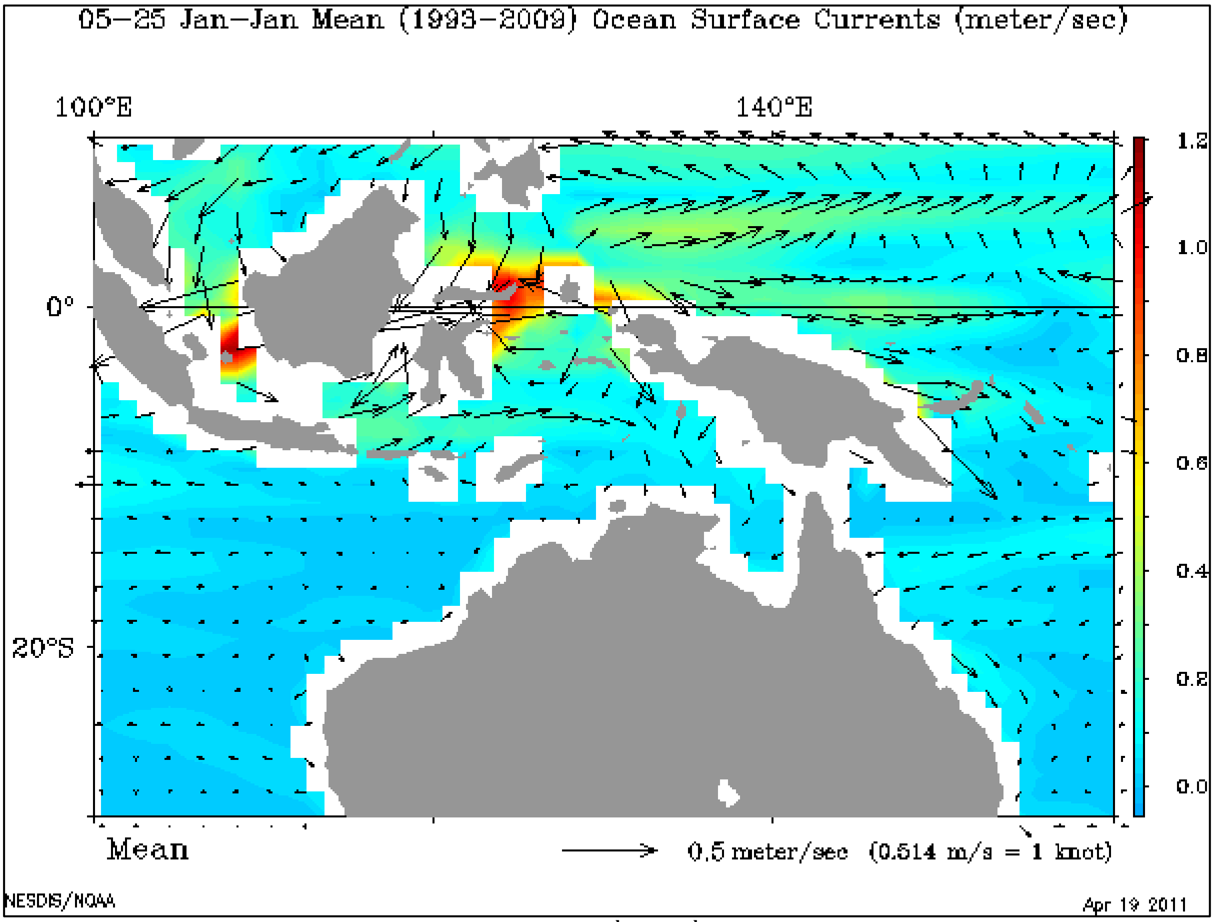


Fig 5.1.3.2: mean surface currents, 5th to 25th January, 1993 to 2009 (10)

5.2. Singapore to Qingdao

This race has perhaps the greatest contrast of climatic conditions, from equatorial swelter to northern hemisphere winter in the space of 3 short weeks.

5.2.1. The Route

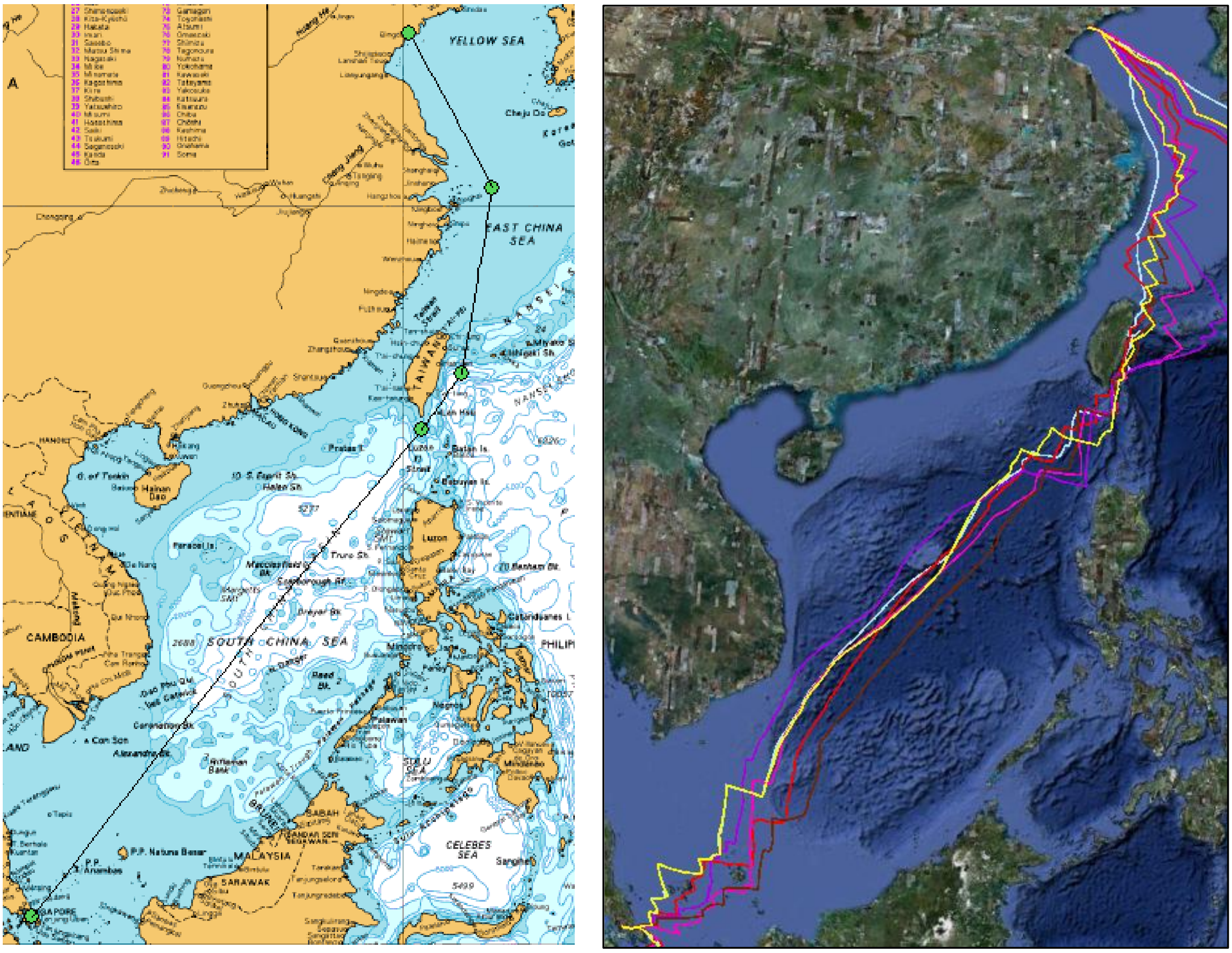


Fig 5.2.1.1: the charted route (left (19)) and the Clipper 09/10 tracks (right)

"Ocean Passages" recommends the Palawan passage for the initial South China Sea section for ease of passage and level of known navigation hazards. However, modern navigation aids and the introduction of the racing element make this more open to interpretation, as shown by all the yachts in the previous race leaving the uncharted areas to the south. Once through the Luzon Straits south of Taiwan the route heads directly for Qingdao, being careful to stay in international waters along the Chinese coast.

5.2.2. The Weather

At this time of year the region is dominated by the Asian high, sitting consistently over Mongolia and eastern Siberia. This causes the NE (in the South China Sea) and N (in the East China Sea and the Yellow Sea) monsoon. These winds increase in average strength to the north, with F4 to about 10^{o} N, F5/6 plus to the Luzon Straits, with more varied conditions to the north of Taiwan. This shows clearly in the mean mast height wind for February for 1948 to 2011 (*Figure 5.2.2.1).* This becomes a hard, unremitting slog in initially very hot, battened down conditions. There are also frequent squalls. (*Section A.1*).

East of Taiwan these winds will be F7 or above for 11 days or more on average in February (20), and are not suited to averaging, so the benign looking condition shown are somewhat artificial.

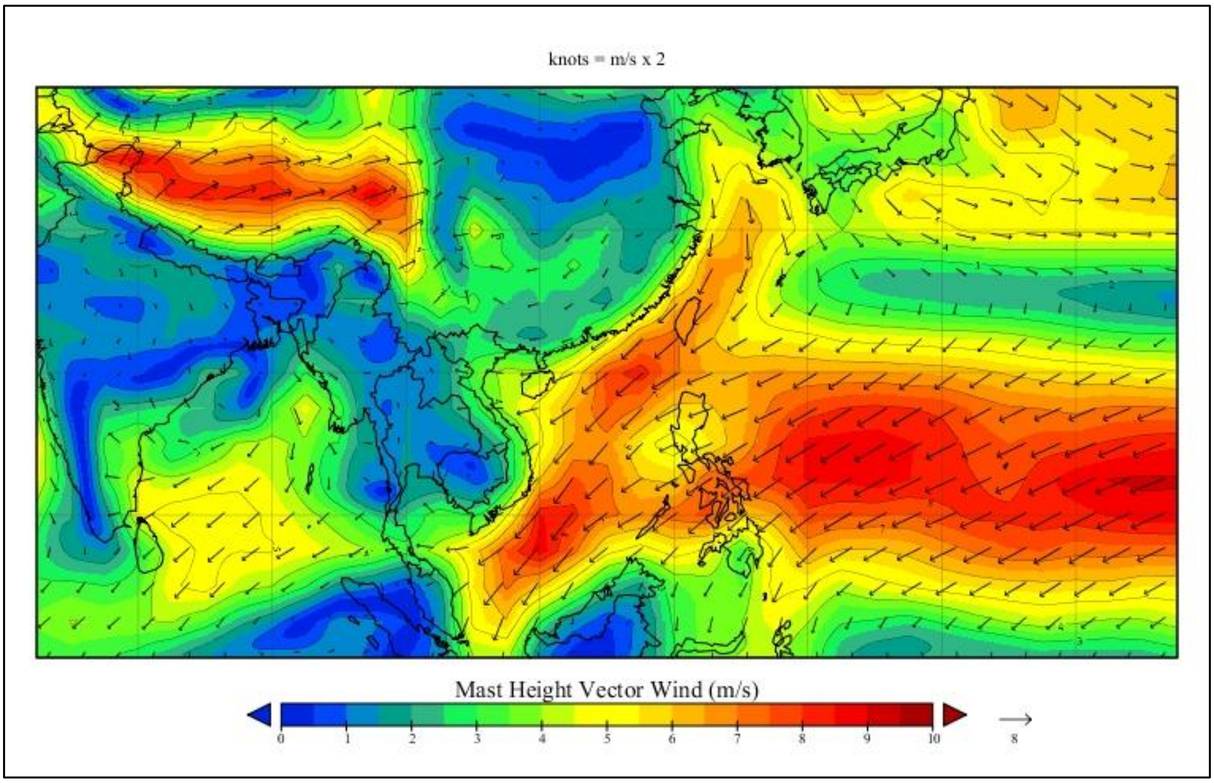


Fig 5.2.2.1: mean mast height winds for February, 1948 to 2011 (5)

North of about 35°N and on the main continental coastline is an area of cyclogenesis, with the N Pacific cyclonic systems starting off here. *Figure 5.2.2.2* shows this, the infra-red image picking up the low clouds associated with the cold front of the developing low. The TIR image shows that the cold front is not yet fully developed as the clouds are not showing up bright white. This implies they are not cold, and so not as high as they will be. It also shows the front reaching down to the Luzon Straits.

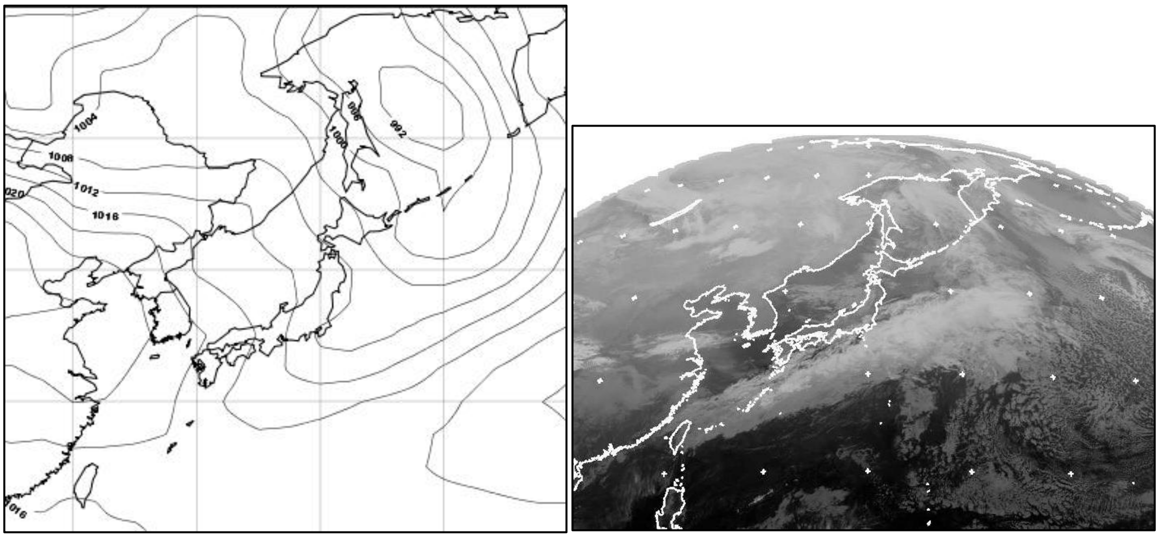
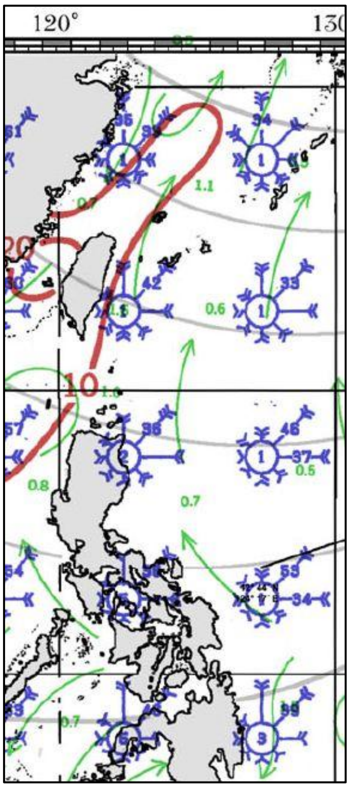


Fig 5.2.2.2: surface level pressure chart (left, hPa, (5)) and thermal IR image (right, (7)) of a developing low north of Japan, 28th January 2010, 1200Z



The Luzon straits and the area just east of Taiwan are areas of potentially severe conditions. The red contour on the routing chart (*Figure 5.2.2.3)* indicates percentage chance of waves over 12 feet. The weather is far more variable too – the area comes under the influence of low pressure systems, as can be seen by the variability of the wind roses and the N monsoon can be augmented by depressions moving away to the NE, bringing winds of F8 or more. The general current direction is to the north, which gives rise to significant wind over current effects (which lead to *Team Finland's* dismasting in the 09/10 race). The effect of the depressions before they move eastwards can be to negate the monsoon, leaving little or no wind and a large residual swell. It is prudent to navigate with caution, and to be continually aware of potential lee shores and changeable weather. This carries on through the Yellow Sea up to Qingdao

Fig 5.2.2.3: routing chart extract for February (4)

The SST drops as the Yellow Sea is reached (*Figure 5.2.2.4)* which leads to a good chance of fog (21). This is usually accompanied by a massive fishing fleet with a somewhat individual take on lights, shapes and the IRPCS in general, making it a very unpleasant place to be. And it's not yellow.

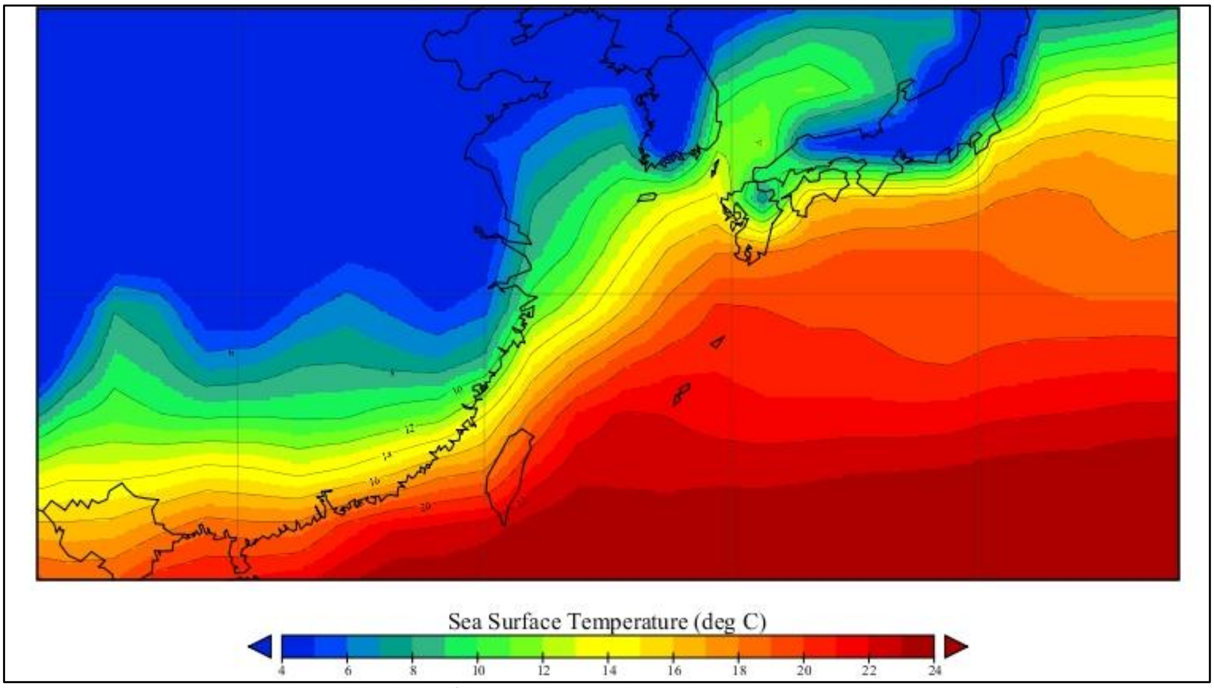


Fig 5.2.2.4: SST (^{O}C) averaged for February, 1948 to 2011 (5)

The air temperature drops too, and this is shown by the thickness of the layer from 1000 hPa to 500 hPa (*Figure 5.2.2.5)*, basically the bottom half of the atmosphere by mass. If this is less than 528 dm it is cold enough that any precipitation will be in the form of sleet or snow, and less than 540 dm with some wind chill will feel below freezing.

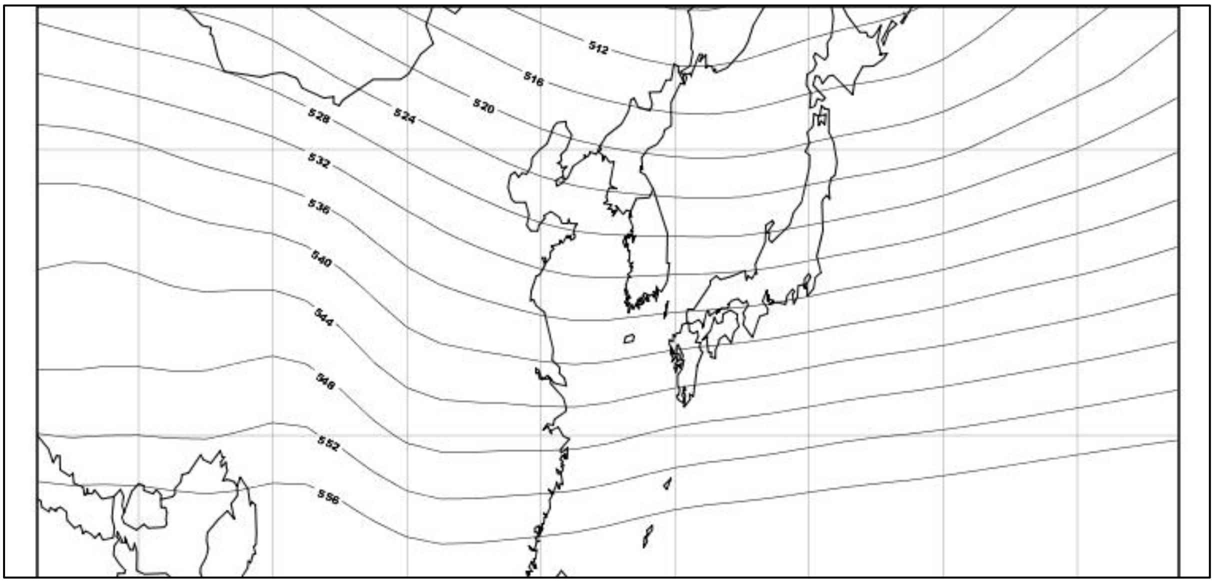
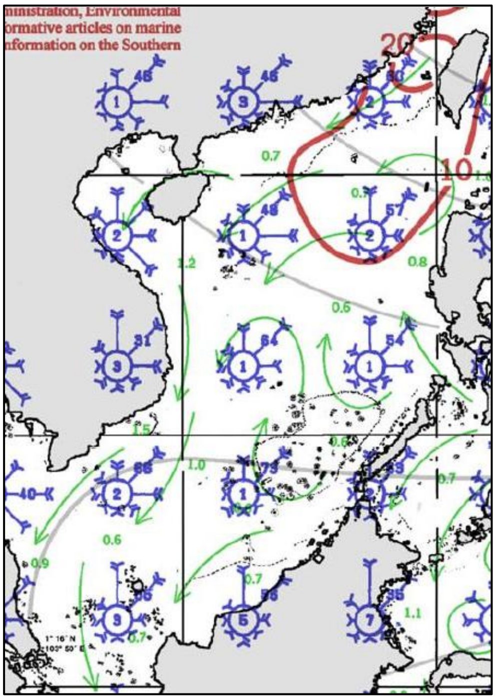
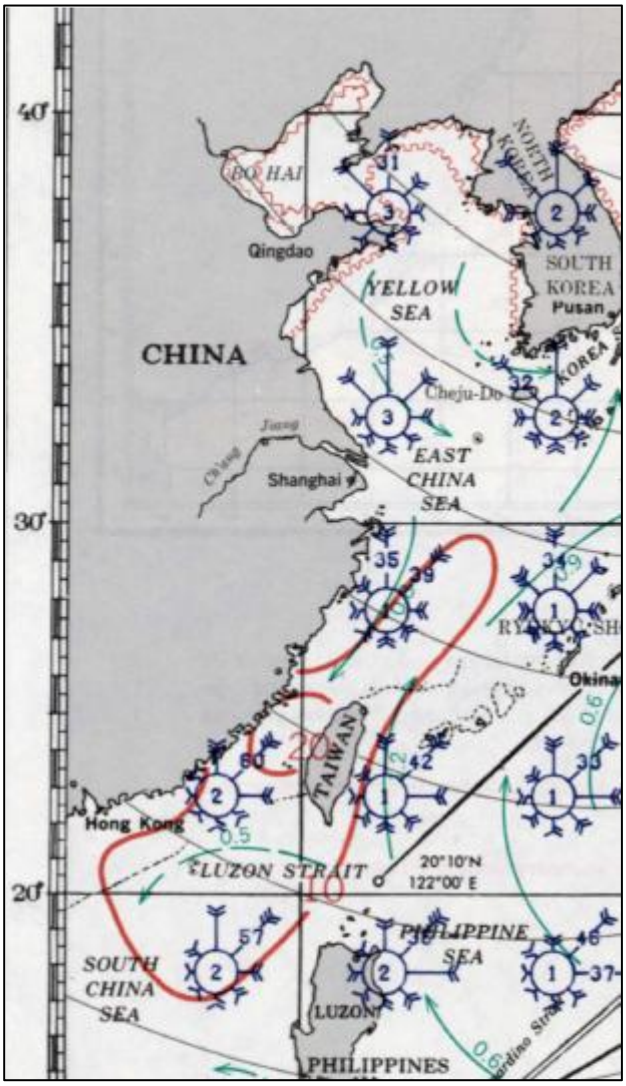


Fig 5.2.2.5: 500 to 1000 hPa thickness (dm – 10's of m) for February, 1948 to 2011 (5)

5.2.3. Currents

Fig 5.2.3.1: routing charts for February (4) for the South China Sea (left) and the east China and Yellow Seas (right)





The routing charts (*Figure 5.2.3.1)* show that in the South China Sea there may be a band of neutral or even favourable current just north of the uncharted area. Also, there is favourable current up the E coast of Taiwan, with uncertain currents in the Yellow Sea. This is confirmed by the average currents for February in 1993 to 2009 (*Figure 5.2.3.2)* which also clearly shows the Japan Current, the Kuro Shio, going NE along the 200m contour. This normally very useful current can give appalling sea conditions in a NE gale. Surface currents in the Yellow Sea are generally wind driven.

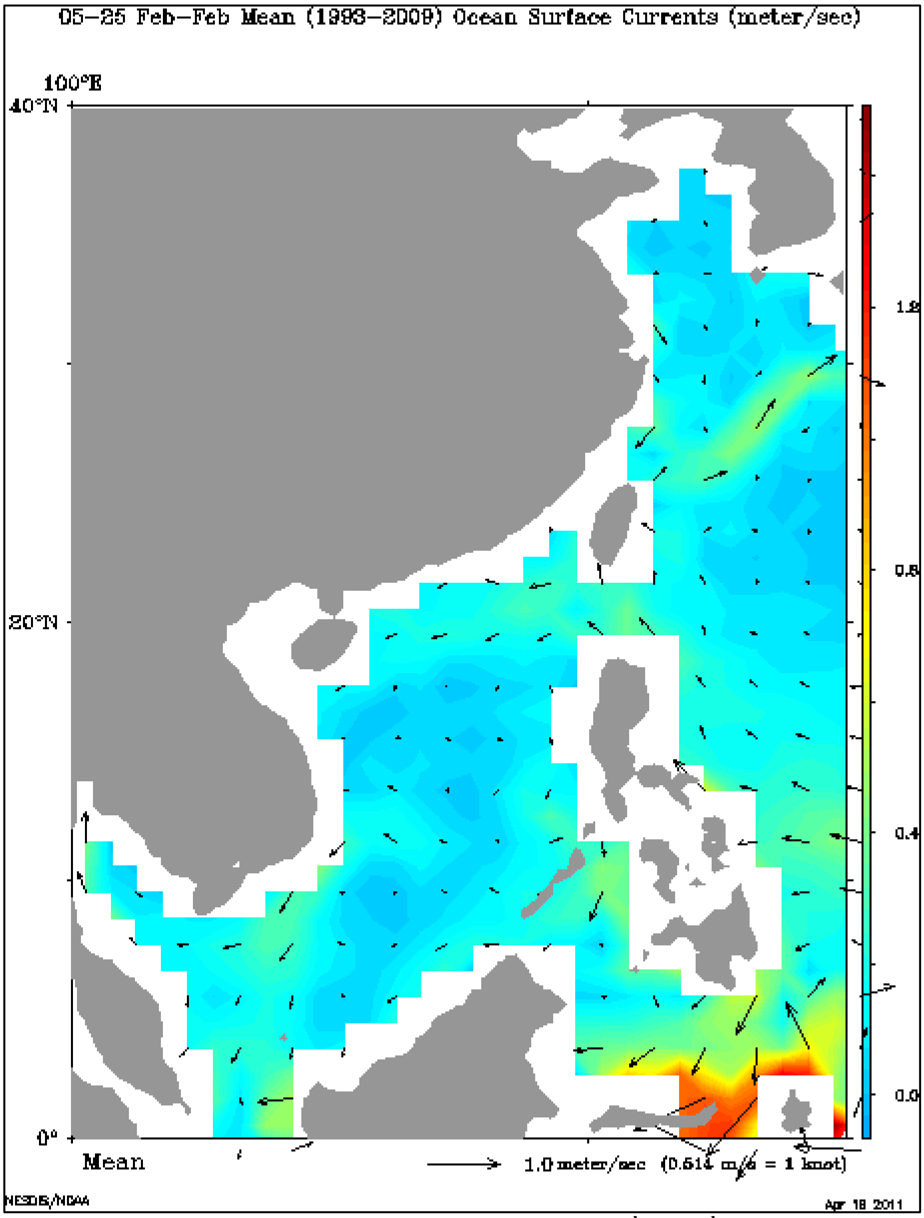


Fig 5.2.3.2: mean surface currents (m/s) for February 5th to 25th, 1993 to 2009 (10)

6. Leg 6 - Qingdao to the West Coast of USA (March to mid April)

This is the longest individual race, and probably has the most severe weather and sea conditions too. The more you and your crew are aware of the possibilities, the better you will be able to overcome them and even enjoy it.

6.1. The Route

The overall route (*Figure 6.1.1)* shows the idealised great circle passage. This does not take into account meteorological or oceanographic conditions. San Francisco is the assumed destination, but this may change, and the northern most point may well be limited by the sailing instructions.

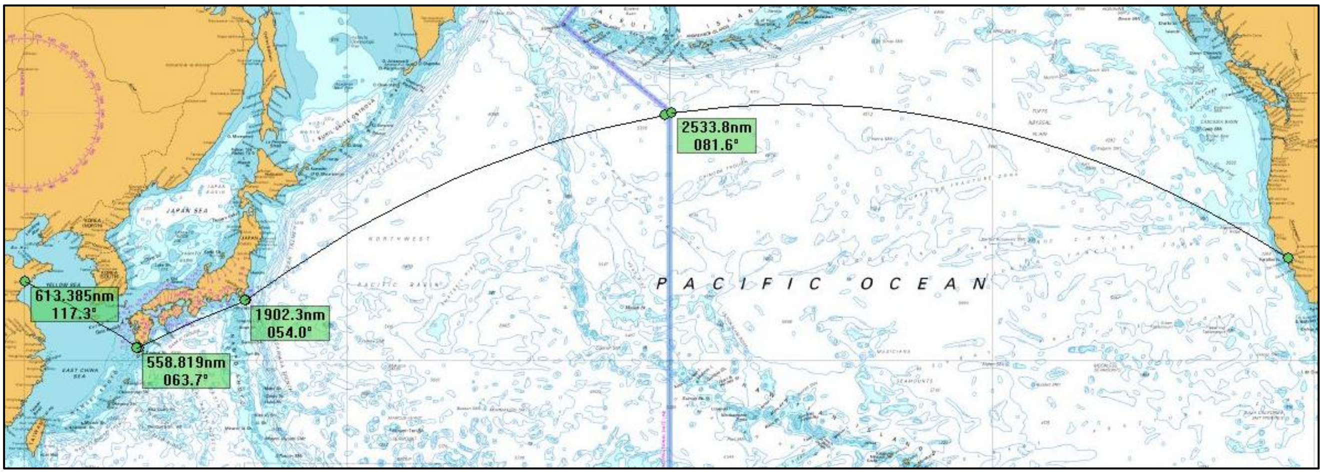
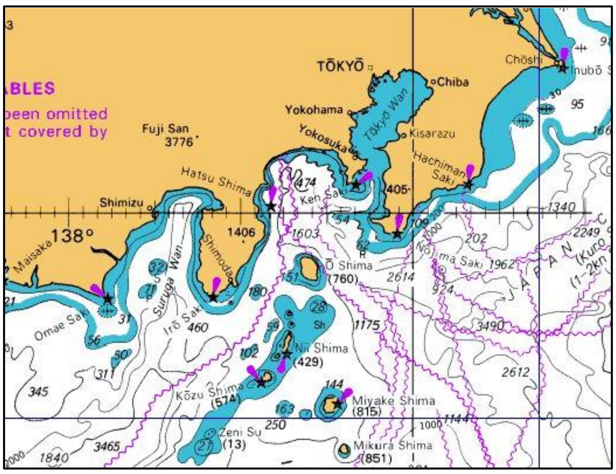


Fig 6.1.1: Overall Great Circle Route from Qingdao to San Francisco (22)

Once clear of the Chinese coast there are few navigational hazards and these are well charted. For most of the Yellow Sea until the 200m edge of the continental shelf the major hazard is other shipping, particularly fishing vessels and their gear. The area is politically sensitive, and it is essential to know of any restrictions or tensions in the area. This information will no doubt be easily obtained from the Chinese authorities in Qingdao.



The islands south of Tokyo Wan (*Figure 6.1.2)* require careful navigation, as the large change in depth, strong currents and frequent high winds cause sea states that can be uncomfortable at best.

Fig 6.1.2: detail showing the islands south of Tokyo Wan (23)

6.2. The Weather

The route, weather-wise, can be split into 3 main sections:

(i) Qingdao to the eastern end of Japan, where it's effectively a coastal race with little scope available in the way of weather tactics;

(ii) Japan to the International Date Line (IDL) – the north west Pacific, which is dominated by the passage of powerful low pressure systems;

(iii) the IDL to California – the north east Pacific, which is dominated by the eastern Pacific High and the lows running to the north of it.

6.2.1. Qingdao to the eastern end of Japan

The Yellow Sea at this time of year will generally have either a northerly driven between the Mongolian High and a developing low near Japan, or an easterly (plus or minus a couple of points) coming from a wide ridge extending over Korea and Japan (*Section 5.2.2).*

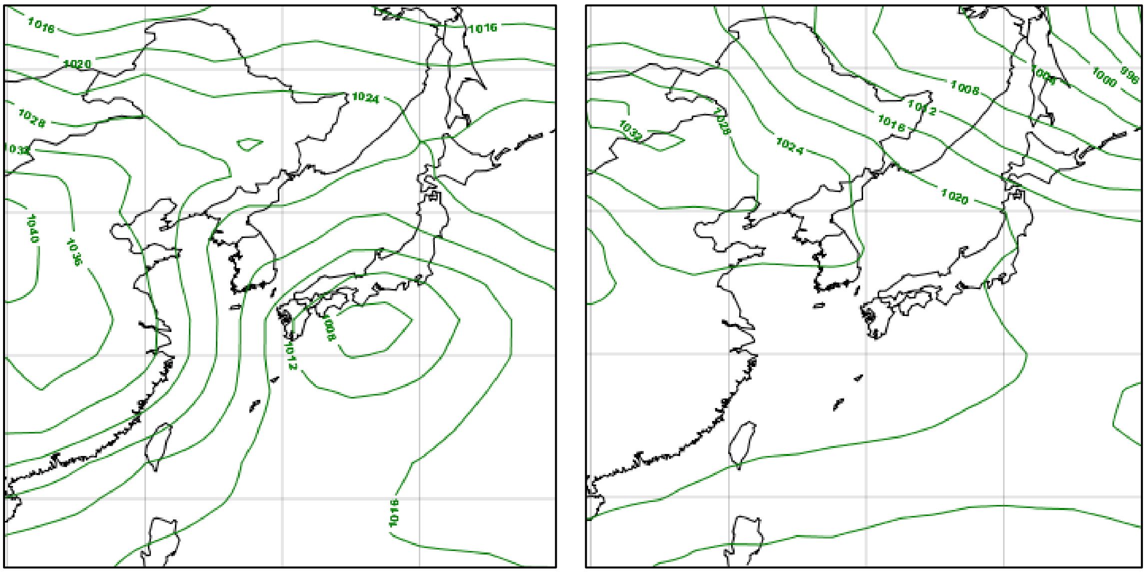


Fig 6.2.1.1: early March 2010 examples of a low near Japan giving N winds (left) and a ridge over Korea and Japan giving E winds (right) in the Yellow Sea (5)

6.2.2. Japan to the International Date Line

Along the south coast of Japan the wind is very much dependent on the position of the nearest low. As this is the area where the lows usually develop, really strong winds tend to occur mostly at the eastern end of Japan (*Figure 6.2.2.1*). This streamline image shows a strong front along the SE corner of Japan, with S to SW 35 to 40 knots before the front veering to NW 25 to 30 knots shortly after it. This is common, and combined with a steeply rising seabed and the Kuro Shio current (*section XXX)* can be rather challenging.

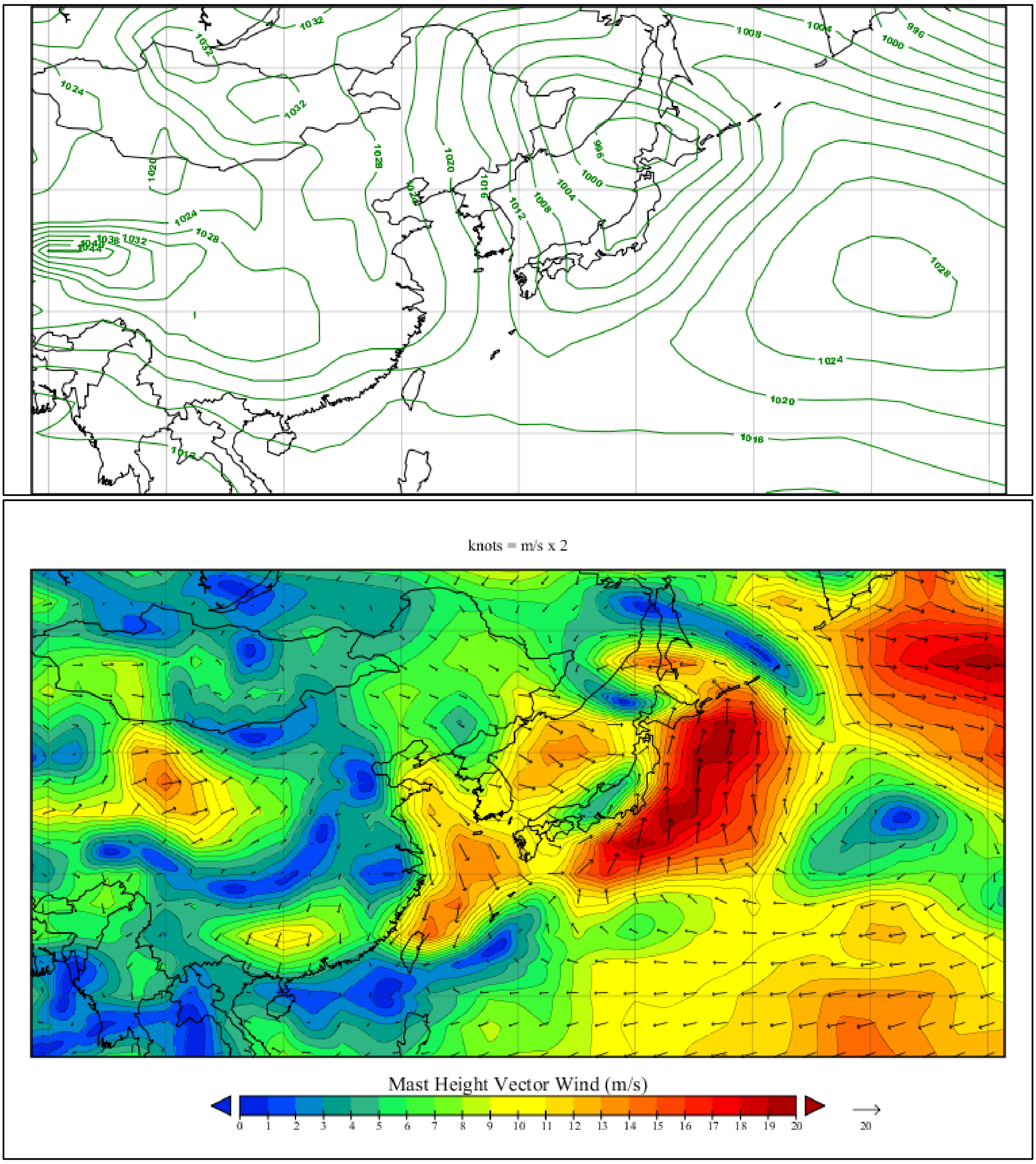


Fig 6.2.2.1: sea level pressure (top, hPa) and mast height vector winds (bottom, m/s) showing a strong front at the SE corner of Japan, 15th March 2010

The high pressure system in the NW Pacific is more fragmented than that in the NE Pacific, and tends to be cells that emanate from the Mongolian high and are moved around by the lows developing in the area. The significant weather systems are the lows that generate near Japan before moving NE towards the Aleutians and Alaska. The path of the centres of the lows (ominously called the "storm track") generally follows to the north of the upper level jet stream, which can be best seen on the 500 hPa wind plots (for example *Figure 6.2.2.2)*. The band of strong 90 knot plus winds is clearly centred at about 40°N to 43°N which gives a good idea of the general location of the storm track. This is also shown by the geopotential height of the 500 hPa level, and the steepest gradient gives the Jet Stream location.

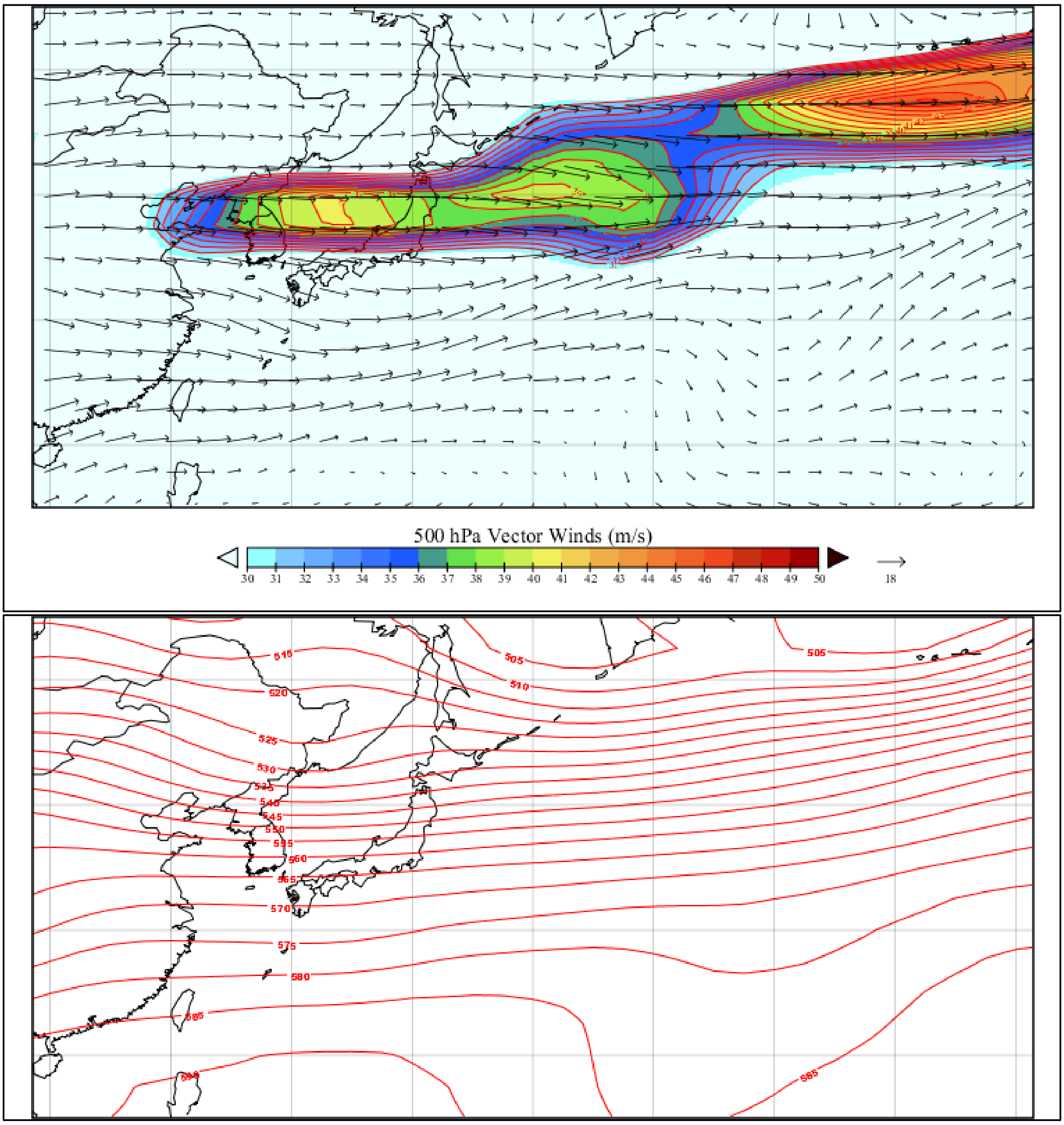


Fig 6.2.2.2: winds (top, m/s) and geopotential height (bottom, dm) at 500 hPa for 2nd March 2010 (5)

However, occasionally the jet stream dips south. Broadly speaking in the northern hemisphere, the areas to the right of the jet entry area (i.e. the start of the 100 knot plus area) and to the left of the jet exit area (the end of the 100 knot plus area) are areas where the upper level winds diverge (*Figure 6.2.2.3)*. This effectively sucks more air up from the surface, causing the low pressure system to "spin up" and possibly reach storm force. This explains why the marked low (*Figure 6.2.2.4)* is a strong one, as it's to the left of the jet exit. The good thing about them is that they occur in the middle of one of the largest stretches of deep, clear water on the planet so there is plenty of sea room. They should be treated with caution, and from experience even hove to a Clipper 68 will still make 4 knots in roughly the right direction in 55 knots of wind from the west.

These lows will generally cross the IDL at about 38^{o} to 45^{o}N, and are not the norm – they are well forecast, both on GRIB and SATC, so there is usually ample time to at least start heading away from the strongest areas.

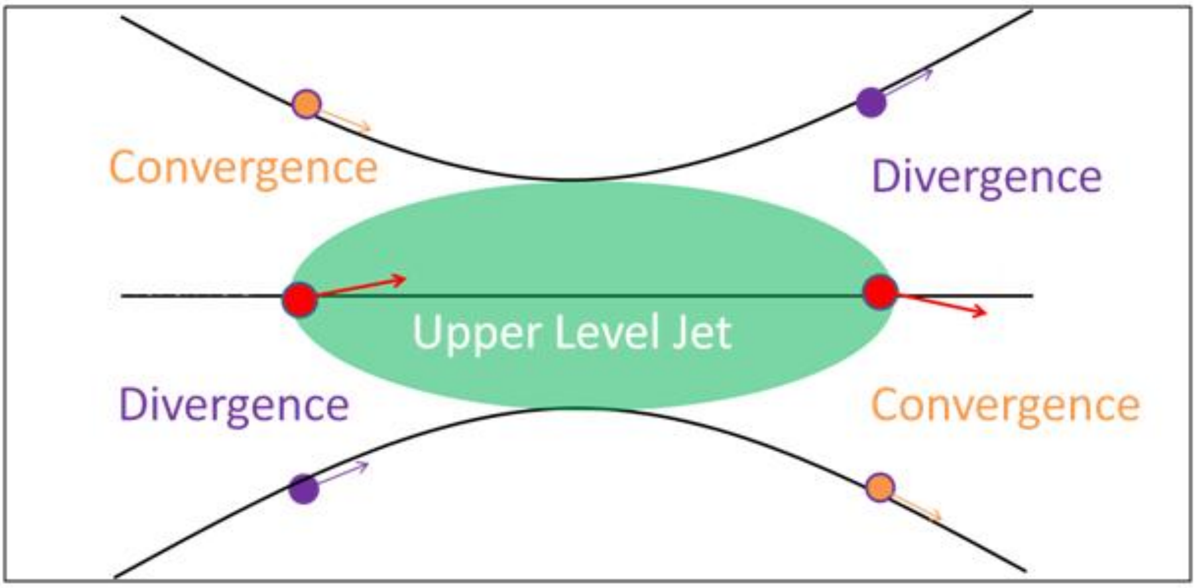


Fig 6.2.2.3: convergence and divergence at northern hemisphere upper levels

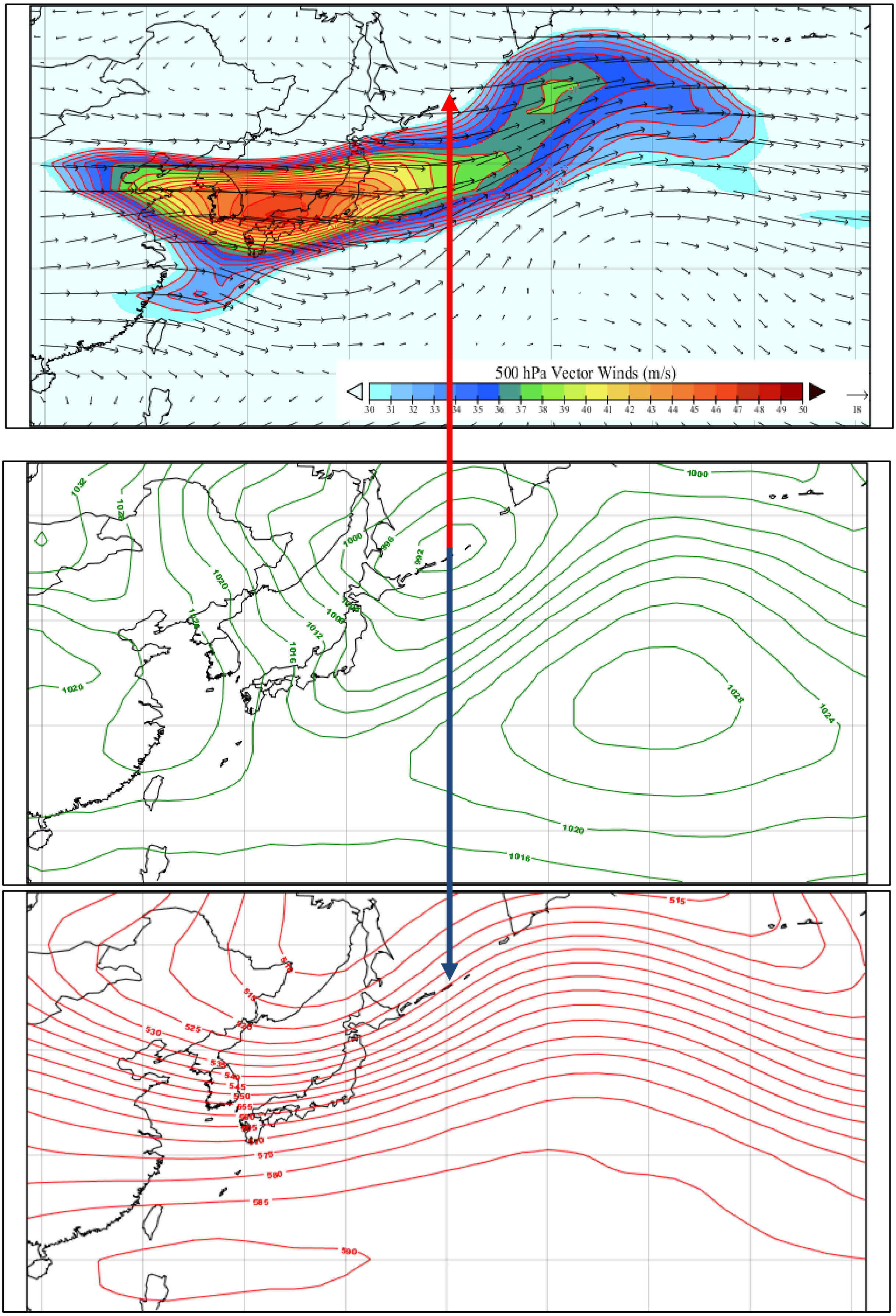


Fig 6.2.2.3: 500 hPa winds (top, m/s), sea level pressure (middle, hPa) and 500 hPa geopotential height (bottom, dm) for March 16th, 2010 (5), with the centre of the surface low marked on the 500 hPa charts

6.2.3. The International Date Line to California – the North East Pacific

There is still a lot of water to be covered from here on in, but the good news is that the low pressure systems have mostly peaked either just before or just after the IDL. The E Pacific high is much more stable, and even the largest low tends to merely change its shape rather than brush it aside. The strongest lows, as described previously, may trail fronts down that almost, but not quite, split the high (*figure 4.7).* These transitions from one high pressure cell to another need to be watched carefully, just as in the Southern Indian Ocean (*Section 3.2)*. The wind down the western seaboard of the United States is entirely dependent on the position of the high – if it's been pushed south by a low it is possible to take a more direct, more southerly route in to San Francisco.

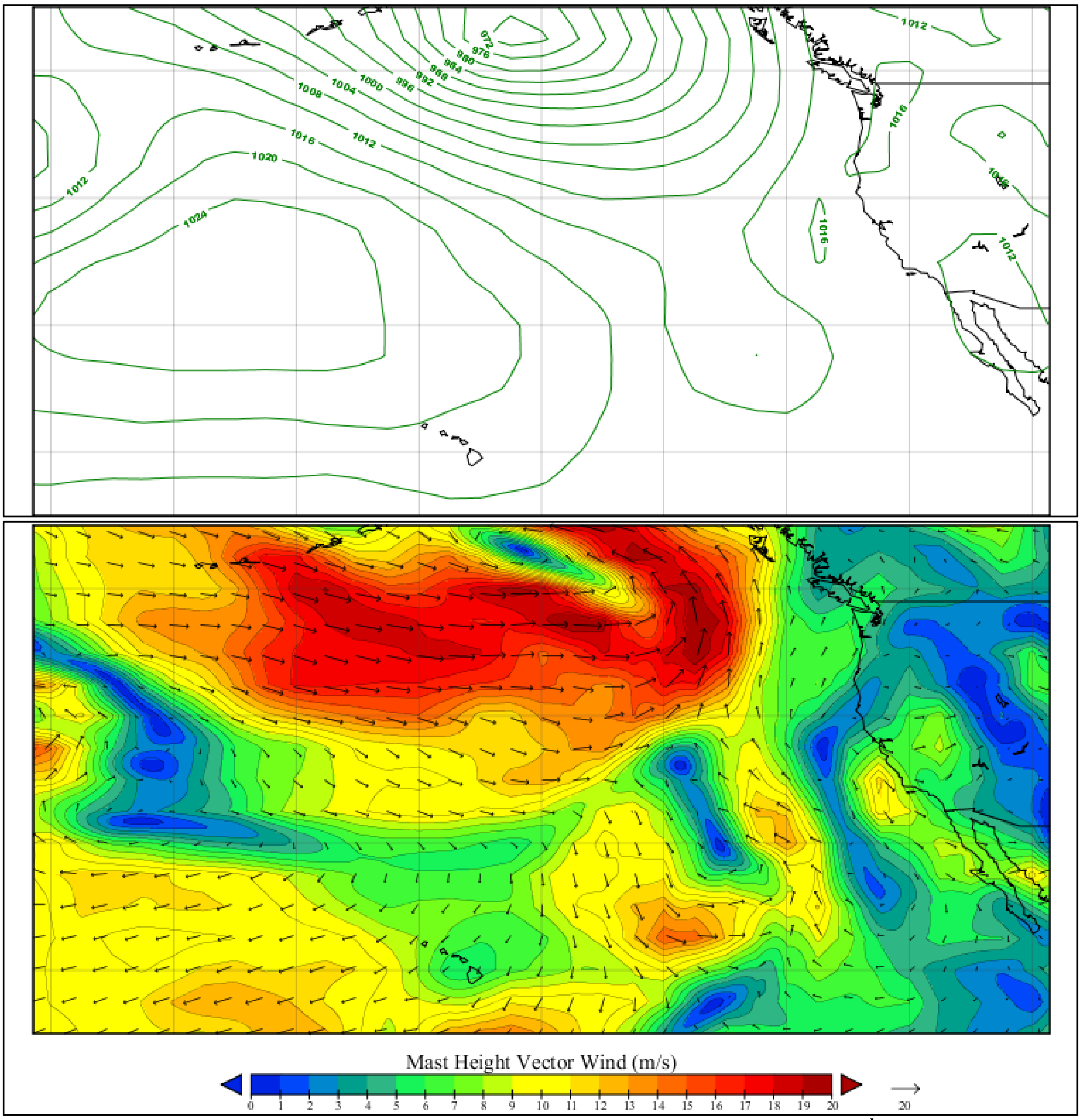


Fig 6.2.3.1: a trailing front splitting the eastern cell of the Pacific Ocean High, 18th April 2010 (5)

The traditional sailing route across the Pacific at this time of year cut the IDL at about 42°N and went due east from there until the winds allowed passage southwards to San Francisco (20). Looking at the mean jet stream, and therefore the general path of depressions, and surface winds for April 1948 to 2010 (*Figure 6.2.3.2)* this is entirely sensible, with a recommended IDL crossing point of between 41° and 42°N.

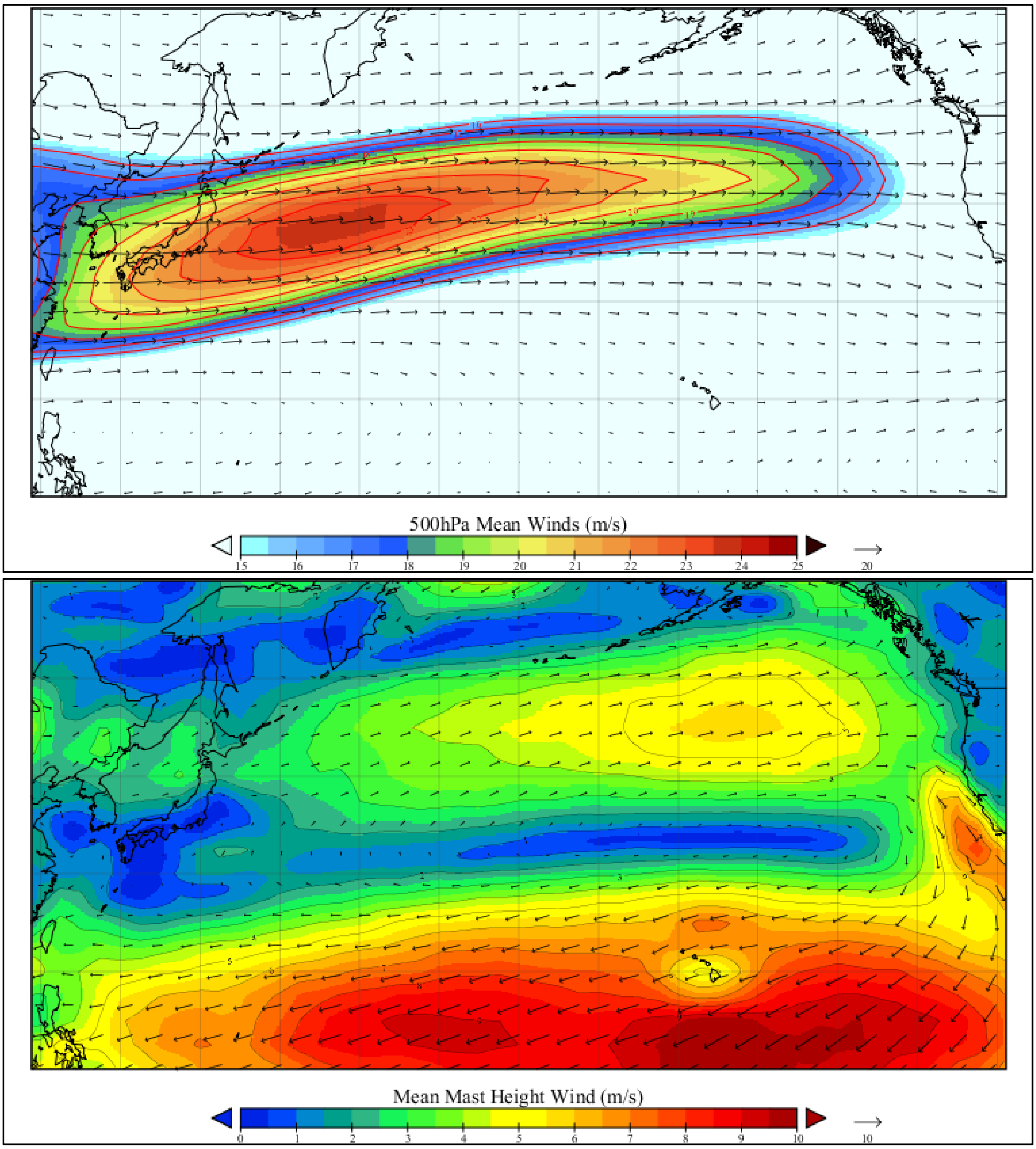


Fig 6.2.3.2: mean 500 hPa (top) and mast height (bottom) winds (m/s) for April, 1948 to 2011 (5)

6.3. Currents

Currents in the Yellow Sea will be mostly wind driven, but once past there the surface current along the south coast of Japan (*figures 2.3 and 2.4)* is the Kuro Shio, or Black Snake. This is the strongest part of the Pacific's western boundary current, and flows at up to 4 knots. It generally coincides with the 200m contour, which happily coincides with the race route. Going through the islands south of Tokyo Wan (*Figure 6.1.2)* can be a bit like being on a cork coming out of a bottle of fizz, with up to 4kts in the channels between the islands. If there is a strong easterly or south easterly, however, the sea state will be brutal in the relatively shallow, confined channels. The best information on the Kuro Shio comes from the Japanese Coast Guard (24), and the Japanese language site has more data than the English version, so it's worth taking pot luck on the options.

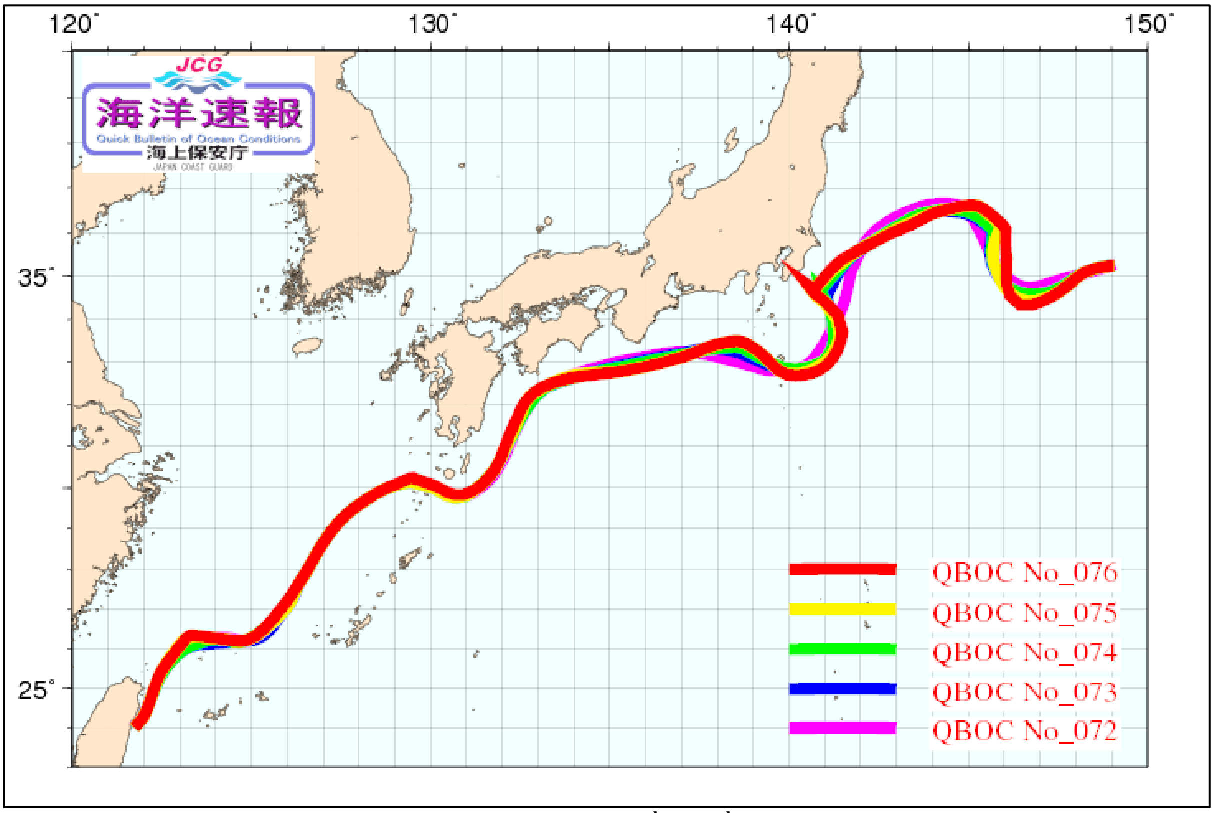


Fig 6.3.1: the Kuro Shio for 22nd to 26th April 2011 (24)

Once the Kuro Shio has been left behind there is nothing apart from the general North Pacific circulation *(Figure 6.3.2)*. SST is a useful proxy for whether the yacht is still in the current or not (*Figure 6.3.3*). The California Current extends nearly 300 miles off the coast, and gives a general flow parallel to the coast of about 0.5 knots or less southwards(25).

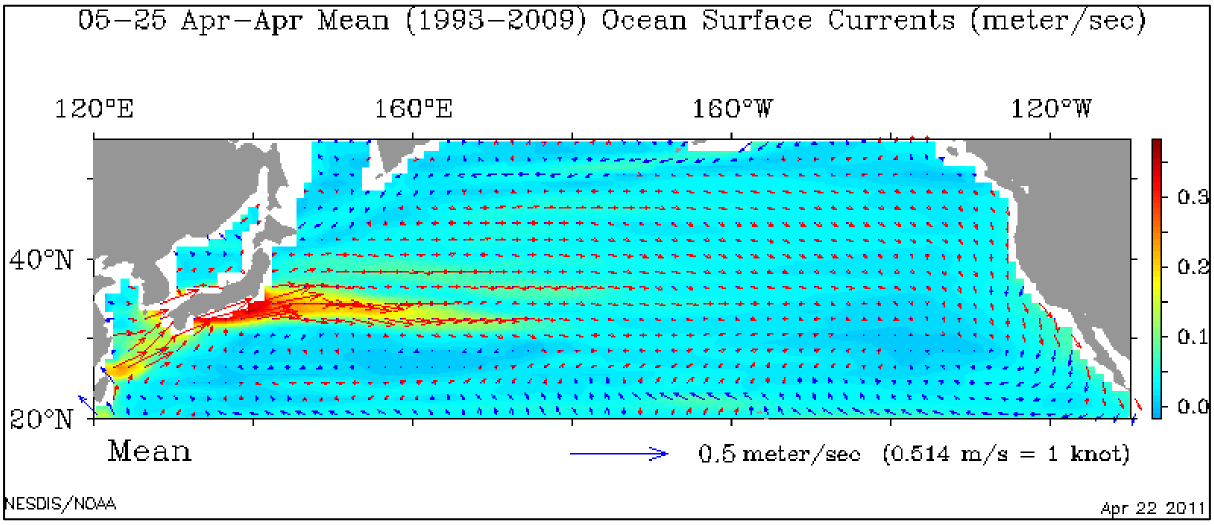


Fig 6.3.2: mean surface currents (m/s) for April 1993 to 2009 (10)

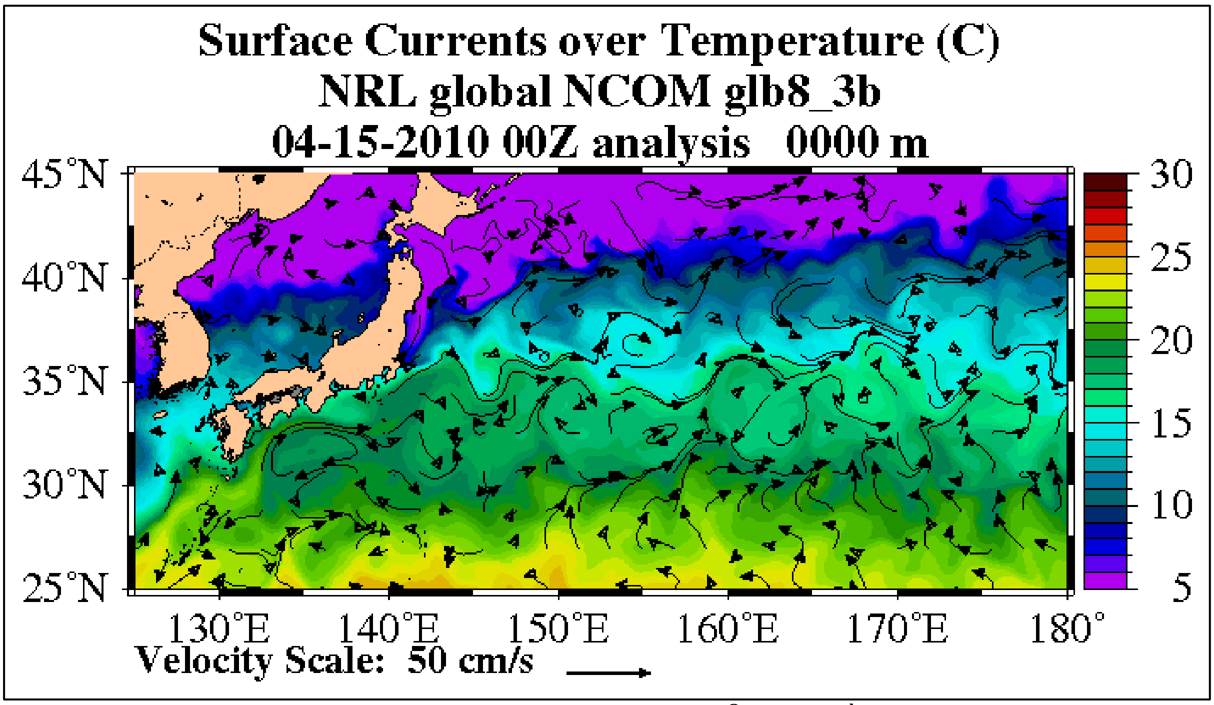


Fig 6.3.3: mean surface currents (m/s) over SST (^{O}C) for 15th April 2010 (12)

<u>**7. Leg 7 – California to New York via Panama (end of April to May)**</u>

The two races in this leg are quite different, and will be treated as separate entities.

7.1. California to Panama (end of April to mid May)

This is about the longest coastal race anyone can do, at about 3300 miles (*Figure 7.1.1).* The route goes from mid-latitude weather down to the ITCZ, so a wide range of conditions will be seen.

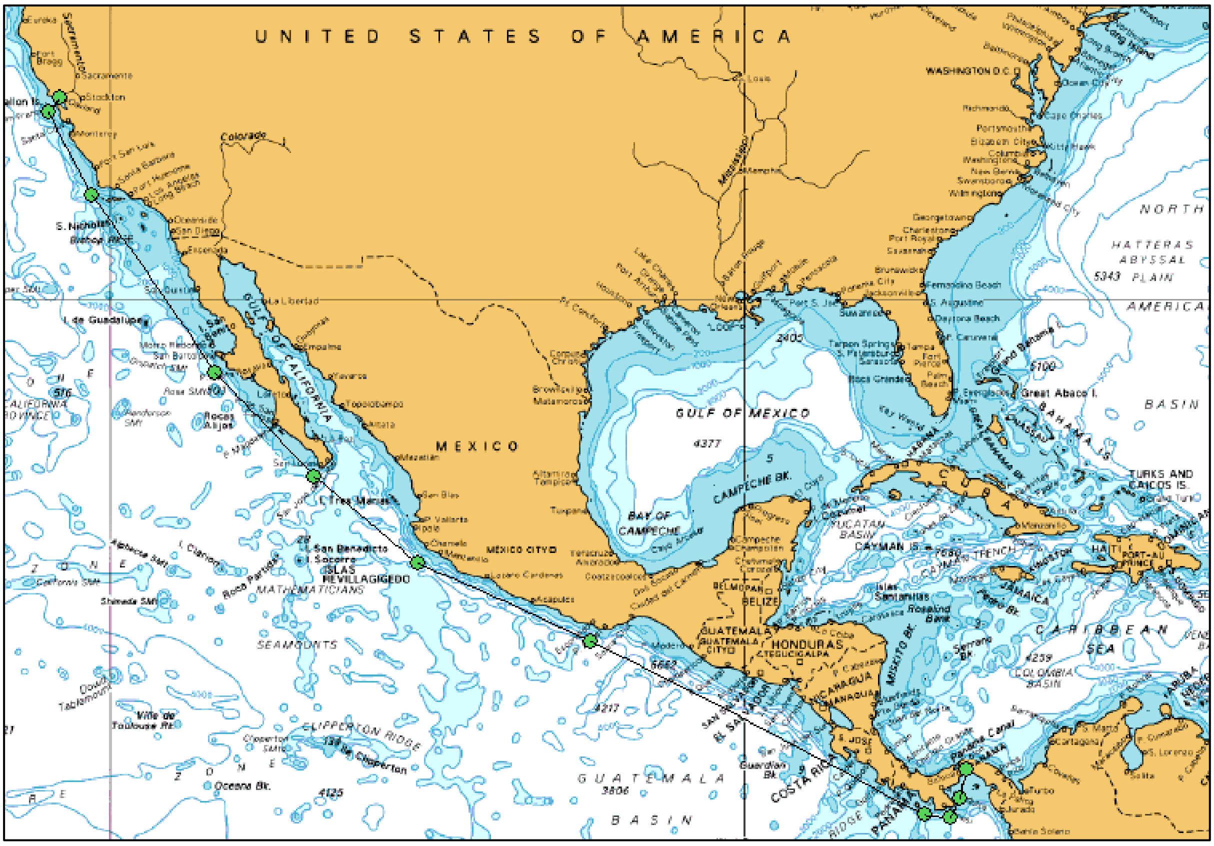


Fig 7.1.1: California to Panama(26)

7.1.1. The Weather

This really is a game of two halves, with decent breeze for the first part circulating around the East Pacific High (EPH), dropping off as you get closer to the ITCZ which at this time of year will be round about Panama (*Figure 7.1.1.1).* The northern part will also be characterised by fronts trailing down from lows transiting the Pacific which can bring strong squalls with them. The winds along the coast are driven by the difference between the pressure over the North American land mass and the EPH. The colder the landmass the higher the pressure and so the less the wind is closer to the coast, so if it has been a particularly cold winter with a late spring then it may pay to stay a little further offshore to avoid the "flat patch" of pressure in between the land to the sea pressure regimes.

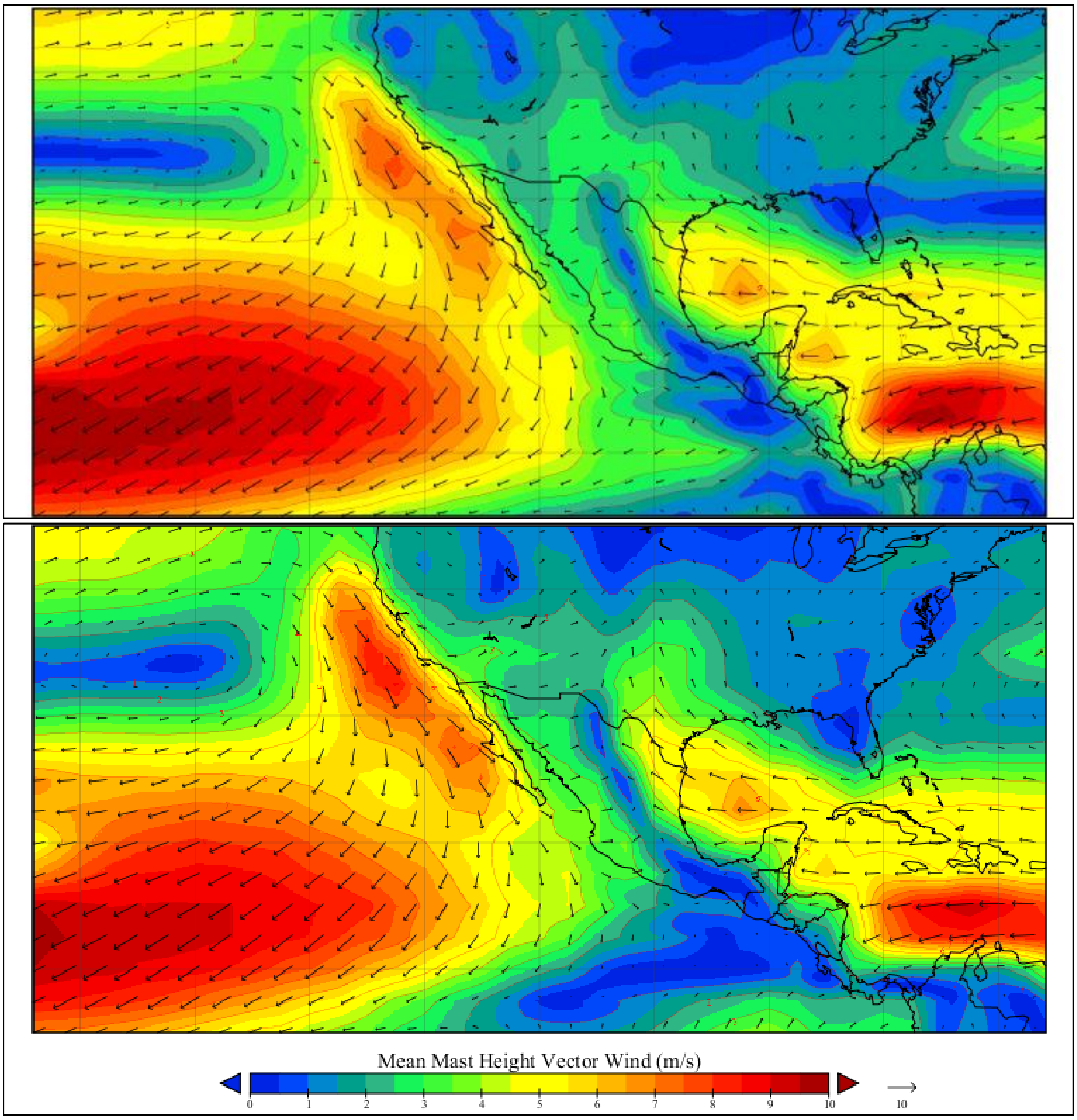


Fig 7.1.1.1: mean mast height vector wind (m/s) for April (top) and May (bottom), 1948 to 2010 (5)

South of about 35^ON there are inshore effects which depend on the local topography (25). The important ones are:

Papagayos between Guatemala and Costa Rica, strong N/NE winds. These should not be too frequent, being winter winds, but may still be present.

Tehuantecepecanos in Golfo de Tehuantecepec (15^ON, 95^OW) which are katabatic in nature and often come out of a clear sky, reaching up to force 10 or 12 occasionally. These are also more prevalent in winter.

Chubascos are violent thundery squalls moving offshore in the warmer waters to the south. These occur in May, and are characterised by the wind suddenly shifting from SW to ENE.

7.1.2. Currents

There are no strong currents here until about 10^{O}N where the Equatorial Counter Current hits the eastern edge of the ocean basin and circulates back on itself (*Figure 7.1.2.1)*. This is not particularly stable, however. The California Current (up to 0.5 knots) sets to the SE along the coast until the S tip of Baja California, and in April and May this gentle SE set will last down to about 10^{O}N.

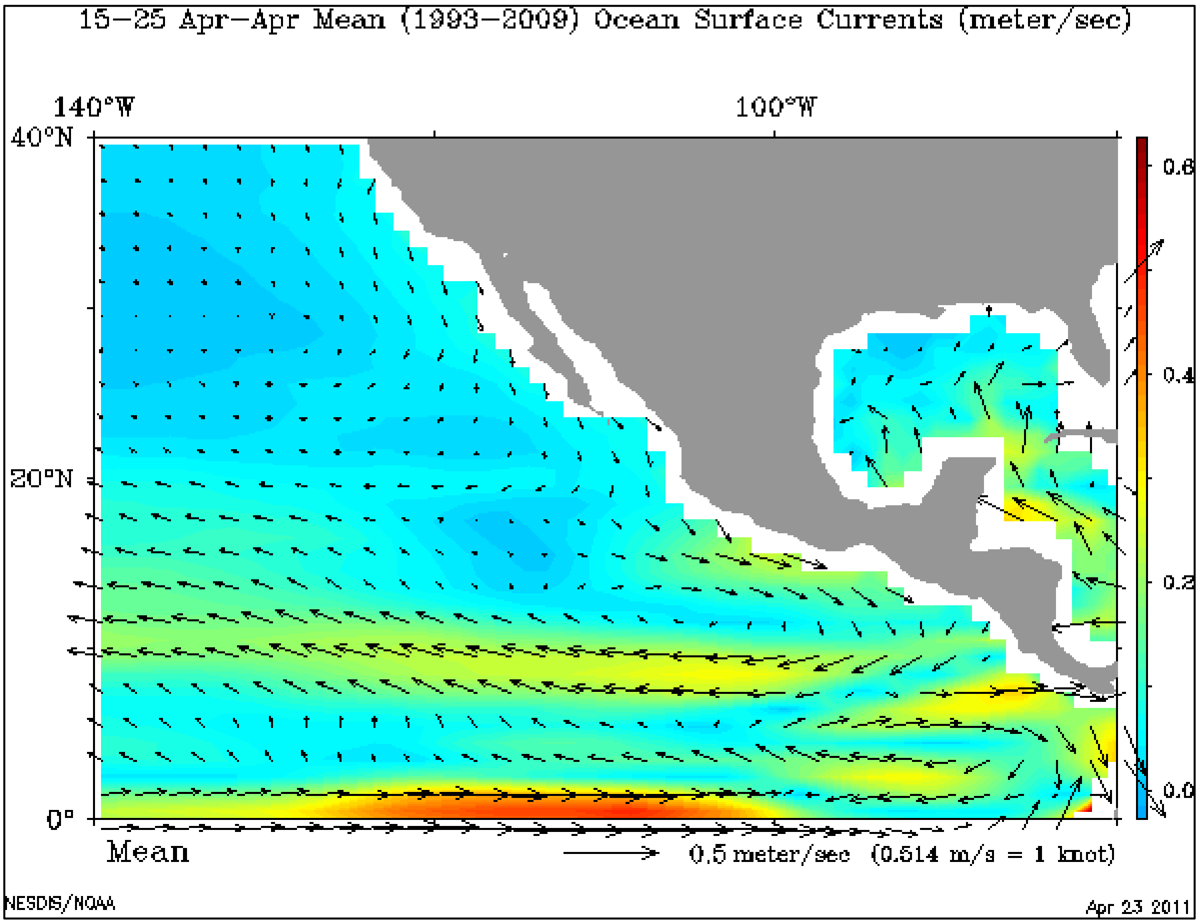


Fig 7.1.2.1: mean surface currents for 15th to 25thApril, 1993 to 2009 (10)

7.2. Panama to New York (May)

This race is tactically interesting, as it consists of several quite distinct sections. As is usually the case, if one yacht gets into the next stage first it will usually gain a difficult to overcome advantage – a classic case of the rich getting richer.

Fig 7.2.1: Colon to New York via the Windward Passage (26)

7.2.1. The Weather

The Caribbean Sea is mostly under the influence of the E/ENE/NE trades in May (*figure 1.1)*, with a very small chance of hurricanes (27). This general trade wind flow is regularly disturbed by tropical waves. These come across every 2 to 3 days and are generally found south of 15^0N. These waves can turn into rotating systems if they drift far enough away from the equator, and can therefore be the source of tropical revolving storms. During May this is unlikely. The surface effect is to back the wind ahead of the wave and veer it afterwards. The wave itself usually has stronger convection activity with more squall activity than usual. Information on these is routinely transmitted via SAT-C.

```
ACTIVE TROPICAL WAVE EXTENDS FROM 8N32W TO 2N34W MOVING W 10-15
KT. THIS WAVE CORRESPONDS WITH AN AMPLIFIED MAXIMUM IN DEEP
LAYER MOISTURE EVIDENT IN TOTAL PRECIPITABLE WATER IMAGERY.
SCATTERED MODERATE/STRONG CONVECTION IS FROM 5N-9N BETWEEN
27W-36W. SCATTERED MODERATE/ISOLATED STRONG CONVECTION IS FROM
2N-4N BETWEEN 31W-35W.
```

Example of Tropical Wave Description on SAT-C

As the ITCZ is around 10^ON in May the very start of the race may be in the Doldrums, but the Trades should be reached by 11^ON or 12^ON. The mean conditions for May (*Figure 7.2.1.1)* show the NAH firmly in place with good Trades up until Jamaica. After this the surface winds depend very much on the location of the western ridge of the NAH and the formation and progression to the NE of lows coming off the North American mainland N of Florida. The 9^{th} May 2010 (*Figure 7.2.1.2)* shows just this, with a large low moving off to the NE dragging a front all the way down to Cuba and causing a huge wind hole just north of Jamaica. When exiting the island chain it is important not to get caught in the lee of any of the islands, particularly in light wind conditions.

Once through the Windward Passage and into the Bermuda Triangle the winds are a cycle of E (± a point or two) Trades, veering to the SW, W and NW as a low goes across, a light patch, and then back to the Trades. This will continue virtually all the way to New York, with a decreasing amount of squall activity as the SST decreases.

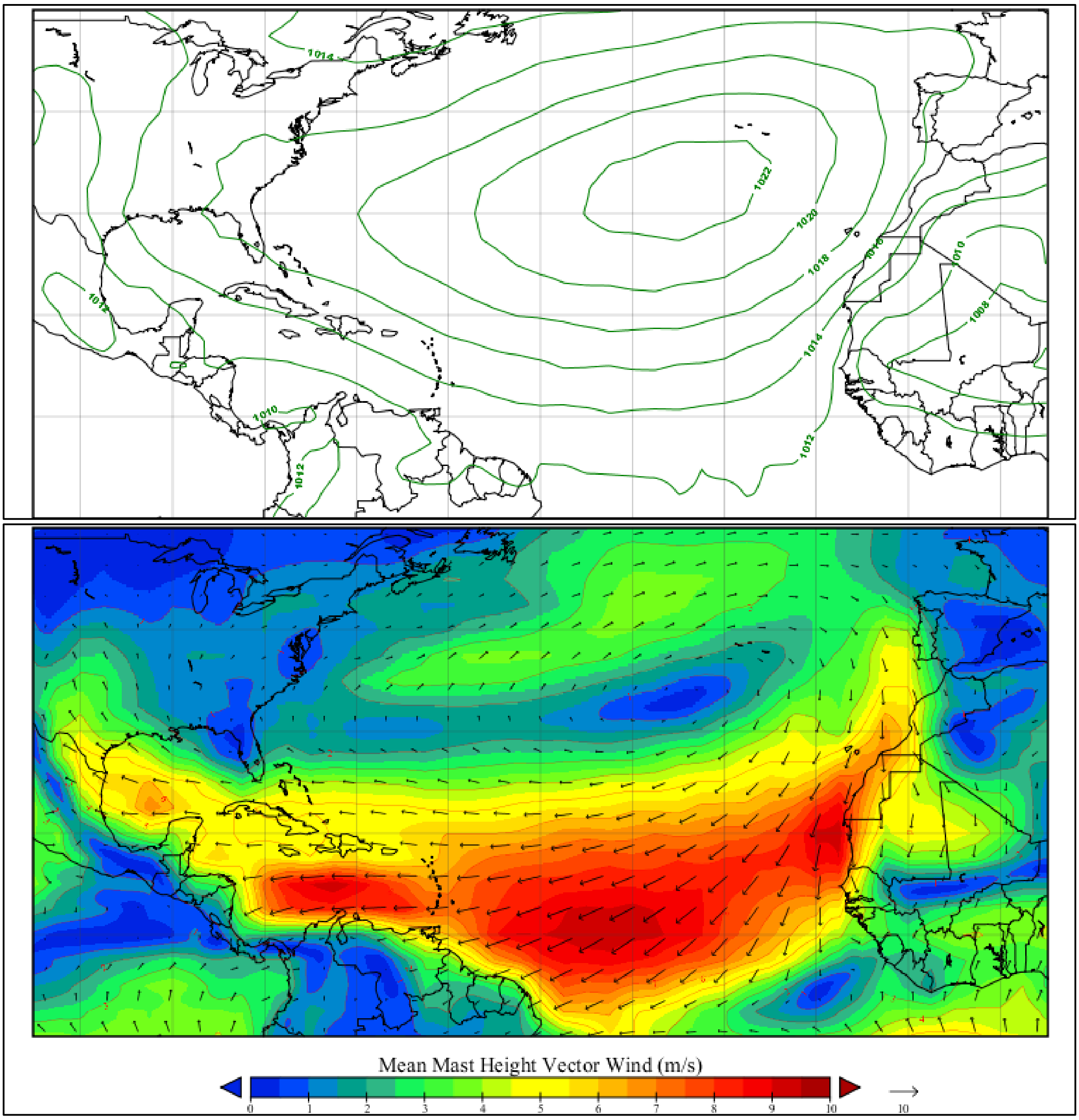


Fig 7.2.1.1: mean sea level pressure (top, hPa) and mean mast height winds (bottom, m/s) for May, 1948 to 2010 (5)

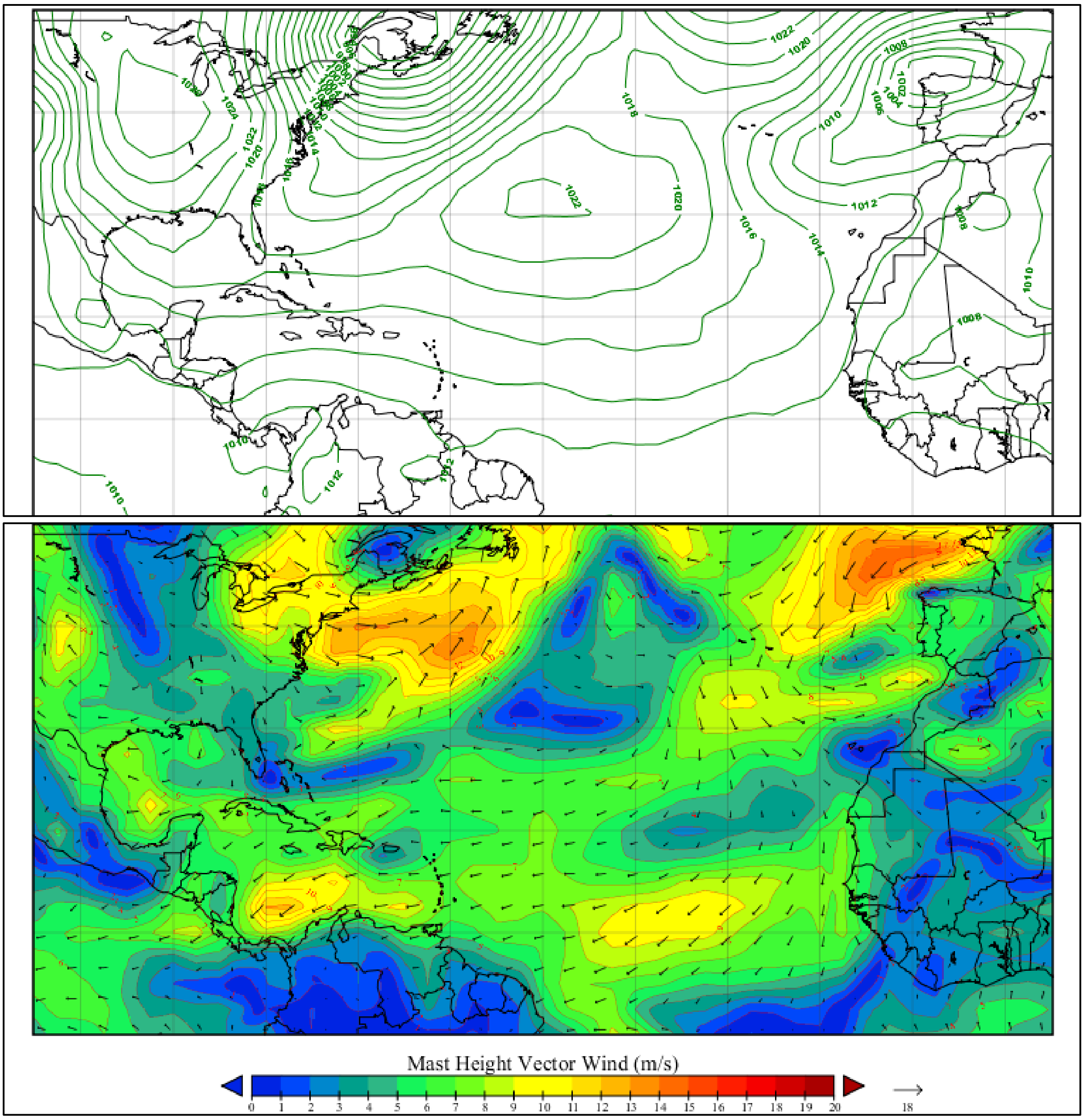


Fig 7.2.1.2: sea level pressure (top, hPa) and mast height winds (bottom, m/s) for 9th May 2010 (5)

7.2.2. Currents

In the Caribbean (sometimes referred to as the Intra-Americas Sea) the current is generally westwards (*Figure 7.2.2.1*). However, south of Jamaica there is often a gyre moving to the west, which can give localised quite strong currents. Sea Surface Height (SSH) plots show this well in warmer waters (*Figure 7.2.2.2*), and this can give significant differences in speed made good between yachts.

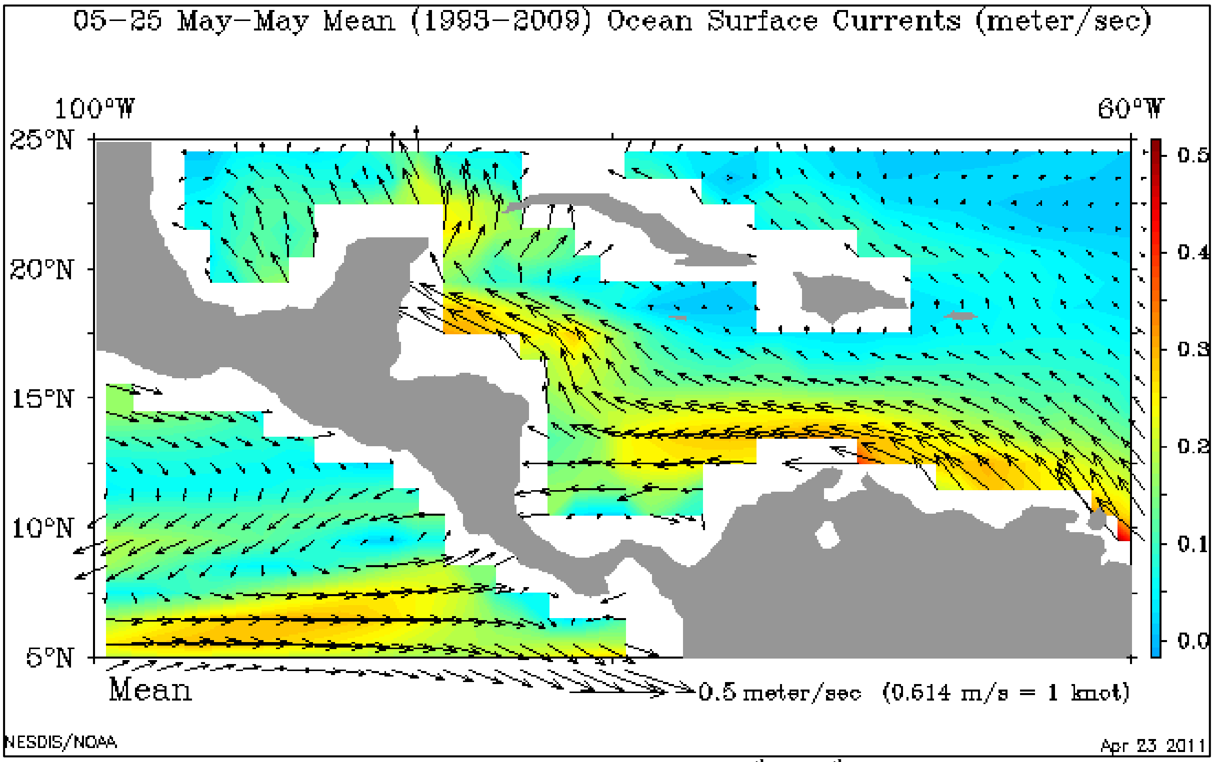


Fig 7.2.2.1: mean surface currents for the Caribbean for 5th to 25th May, 1993 to 2009 (10)

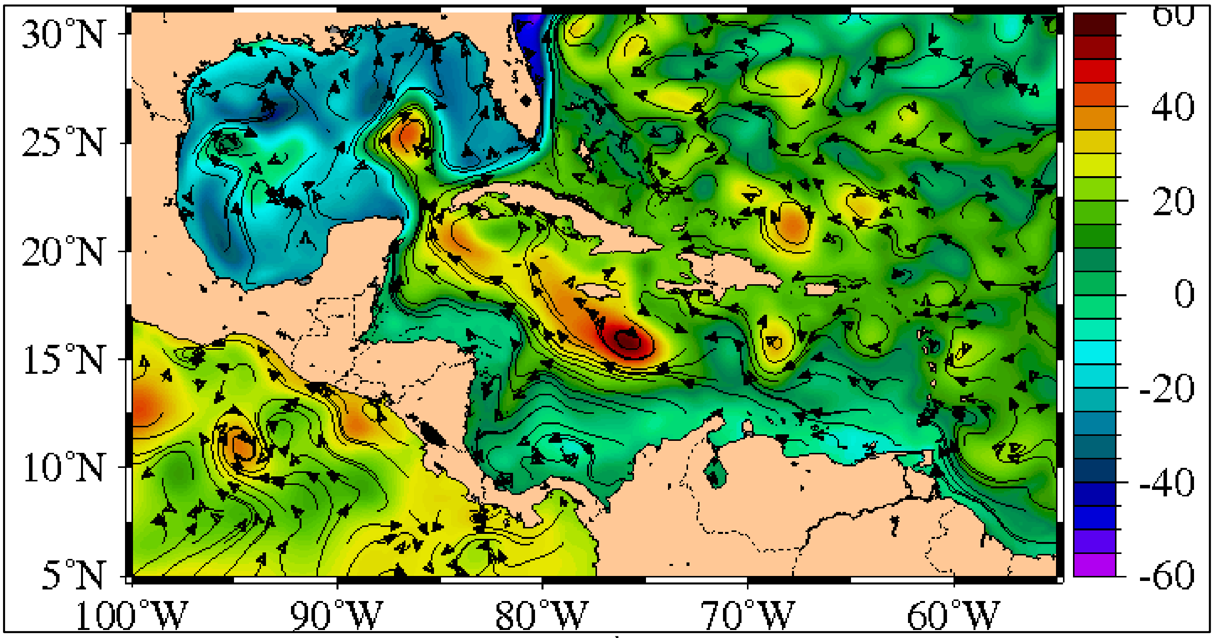


Fig 7.2.2.2: surface currents over SSH (cm) for 11th May 2010 showing the gyre SE of Jamaica (12)

Currents going between the northern islands while exiting the island chain north of the Windward Passage do have some localised differences, but are not as important as not getting caught in the lee of an island, particularly in the likely case of having light winds at this point.

From here to New York the first part to just S of Cape Hatteras at 35^{O}N is in the general anticlockwise circulation around the NAH. At or a couple of degrees S of Cape Hatteras however the direct route to NY conveniently passes over the Gulf Stream (*Figure 7.2.2.3)* which forms the western boundary current of the North Atlantic gyre, and flows up the 200m contour (as a reasonable approximation) at up to 2 or 3 knots. As with all currents there are eddies coming off it on a day to day basis (*Figure 7.2.2.4).* If the wind is blowing strongly from the N or NE the sea state can become short, sharp and unpleasant.

Once onto the continental shelf approaching New York the surface currents become far less steady, and tide becomes the dominant influence.

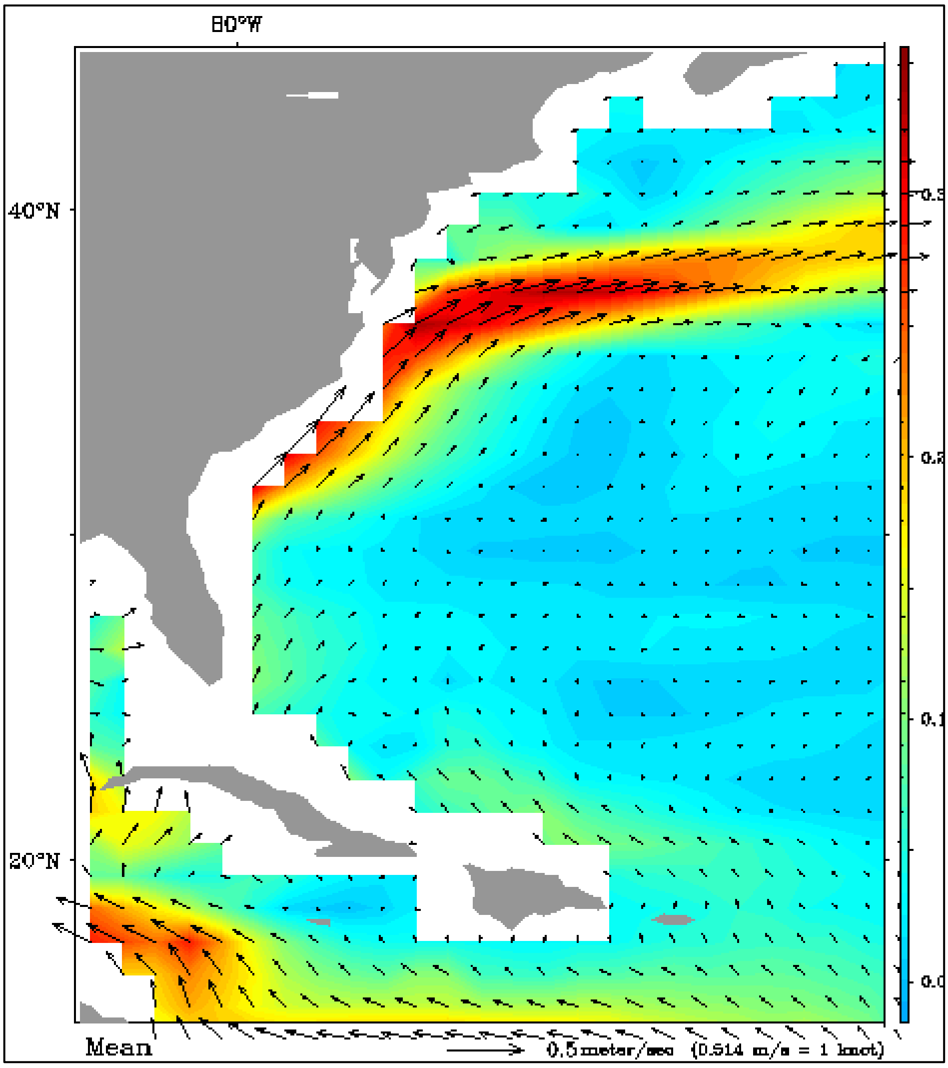


Fig 7.2.2.3: mean surface currents for 5th to 25th May, 1993 to 2010 (10)

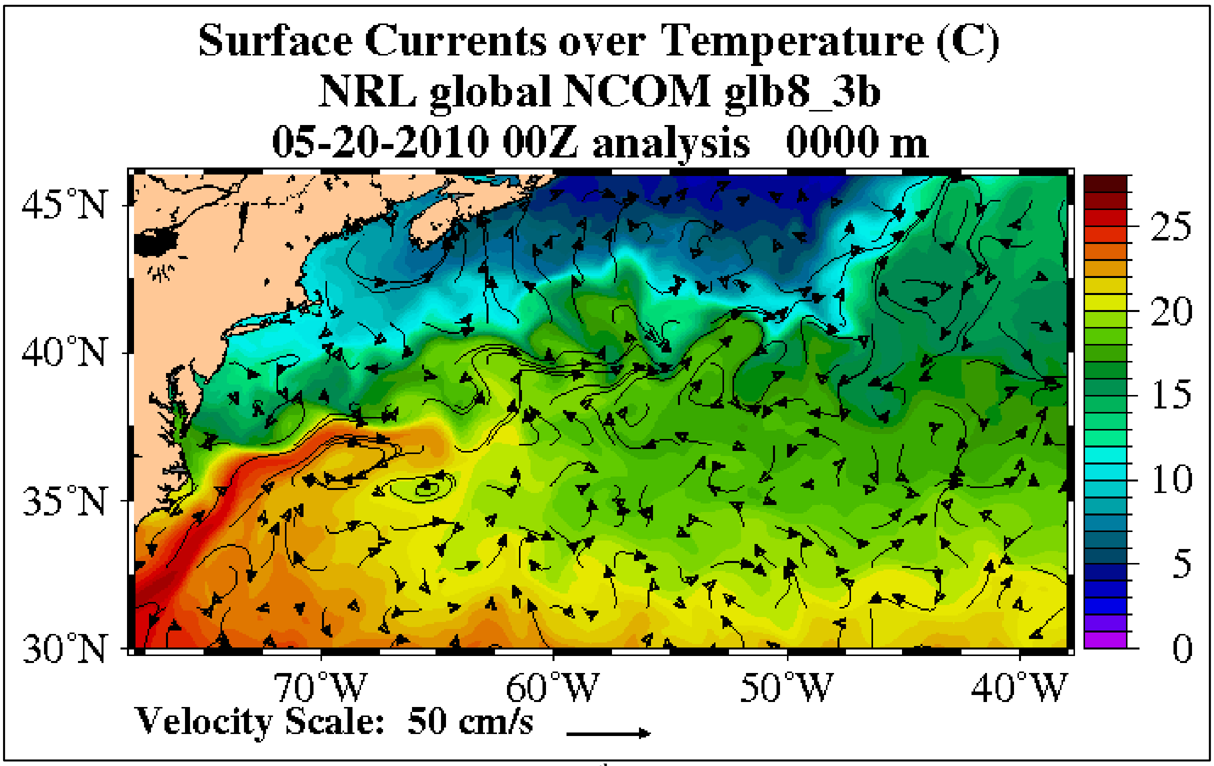


Fig 7.2.2.4: surface currents (cm/s) over SST for 20th May 2010 showing eddies off the Gulf Stream (10)

8. Leg 8 – New York to Nova Scotia and then Derry (June to July)

This leg is firmly fixed in mid-latitude weather, with the main differences being brought by the interaction of the atmospheric conditions with the very different ocean surface movements and temperatures.

8.1. The Route

This goes along the coast from NY to Nova Scotia, then across the Grand Banks, near Flemish Cap *(Figure 8.1.1)* and into the North Atlantic, before returning to the very tidal waters around the UK, Ireland and the North Sea *Figure 8.1.2)*.

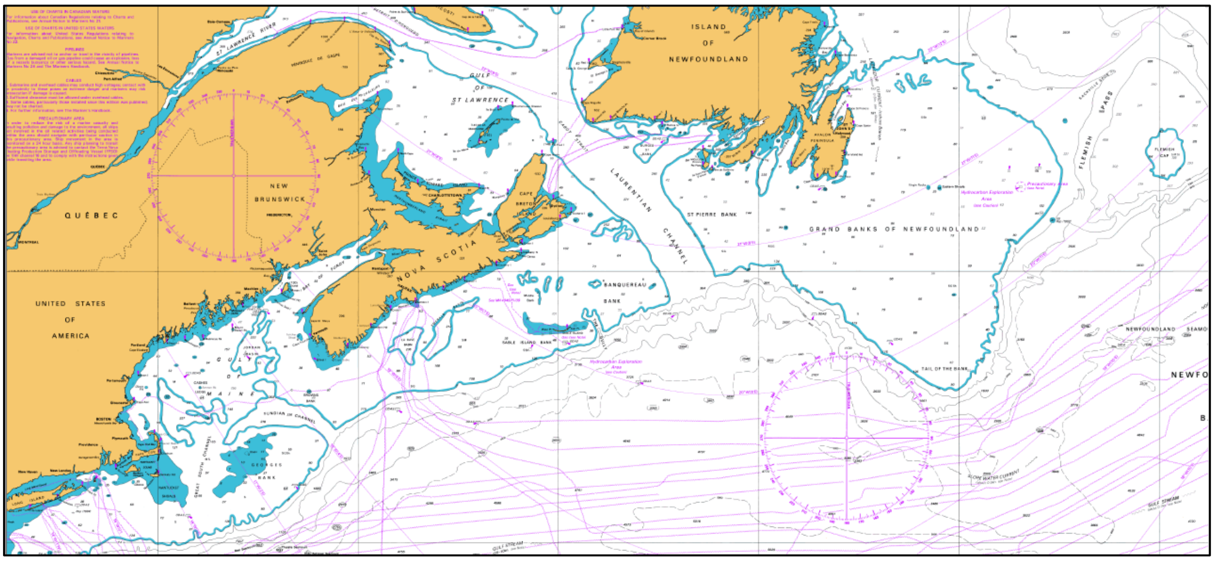


Fig 8.1.1: New York to Flemish Cap (28)

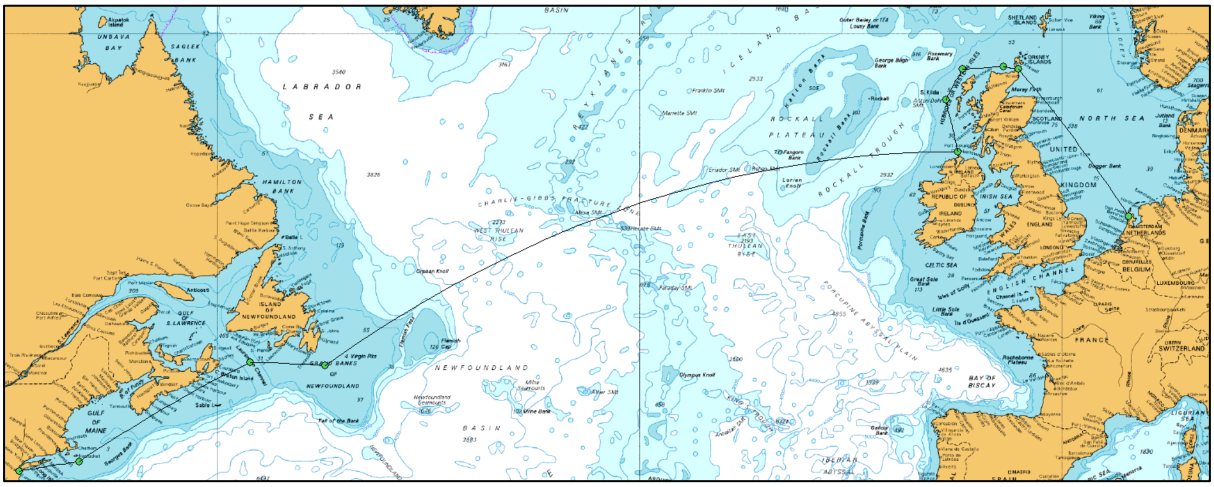


Fig 8.1.2: the overall route

8.2. The Weather

The overall pattern is that of lows generating either over the north-east of the North American continent and travelling mostly eastwards or north eastwards across the Atlantic, generally passing somewhere between Scotland and Iceland. The trans-Atlantic race is one of the few full ocean races that it is possible to get reasonably good forecasts for to last the entire duration.

The usual procession of surface lows across the Atlantic follow the path of the upper level jet stream, which, generally speaking, lies across the UK. The 500 hPa geopotential height and wind speed means for June (*Figure 8.2.1)* show this.

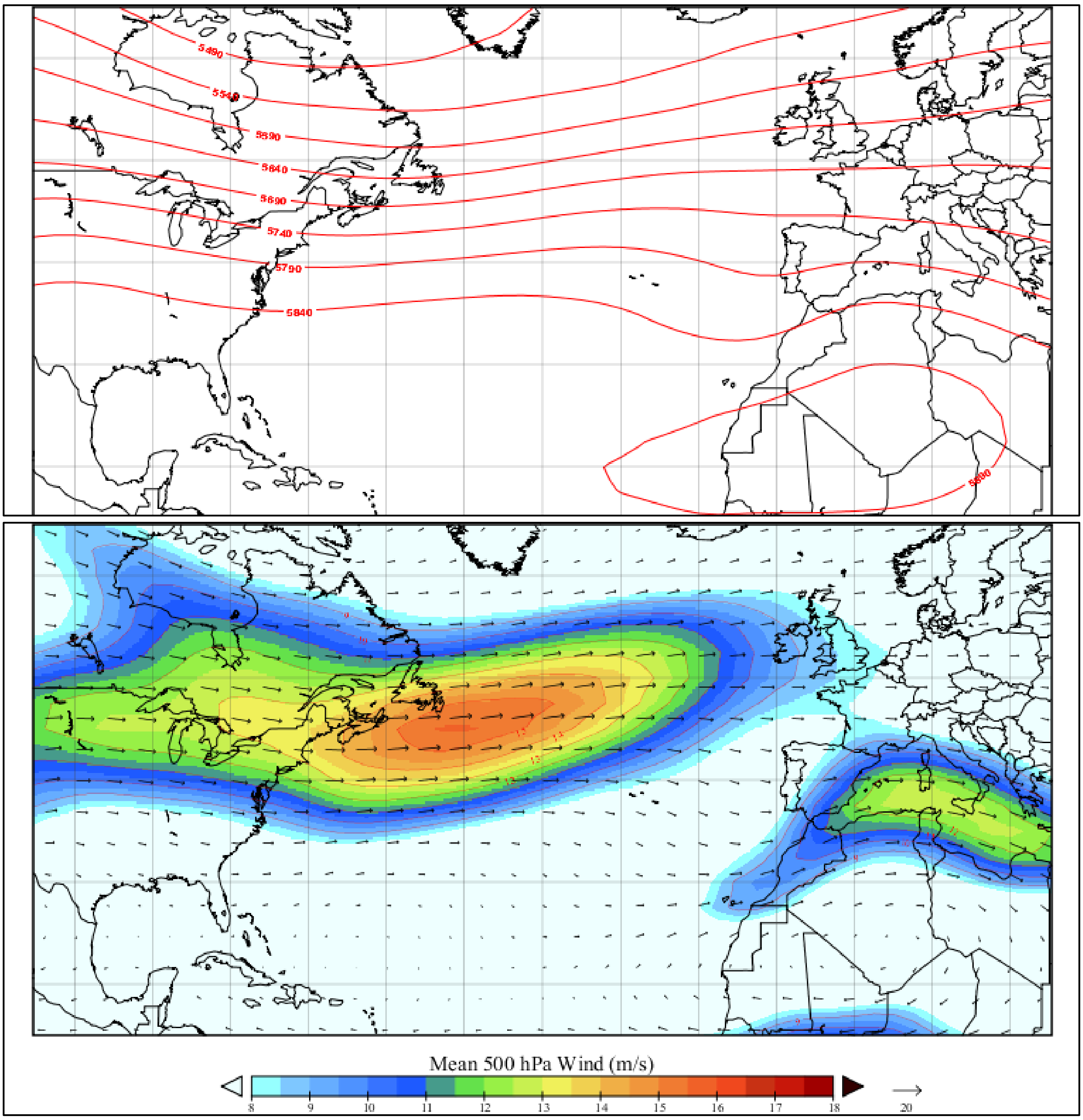


Fig 8.2.1: mean 500 hPa geopotential height (top, m) and winds (bottom, m/s) for June, 1948 to 2010 (5)

This upper level activity (note the well –developed Saharan heat low shown by the highest 500 hPa height) gives mean surface conditions with the NAH generally sending a ridge towards the Bay of Biscay *(Figure 8.2.2)* which means that the NAH only has to drift north a little to block a fast passage for the last few hundred miles into Derry – the most frustrating ones to bob about in. At the other end if the western ridge goes north there will be light conditions for the New York – Nova Scotia race too.

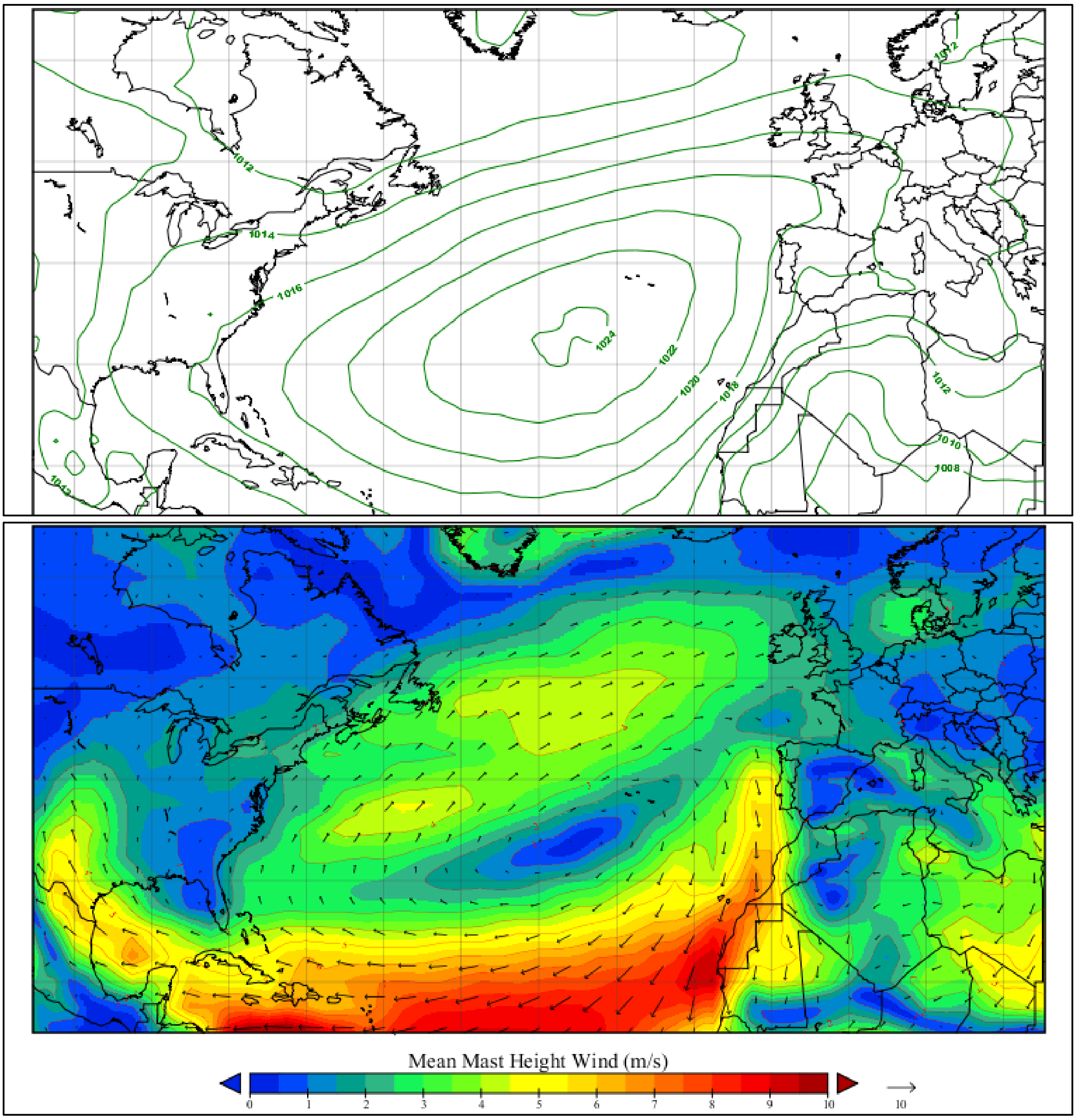


Fig 8.2.2: mean surface pressure (top, hPa) and mast height wind (bottom, m/s) for June, 1948 to 2010 (5)

The progression of lows across the North Atlantic often proceeds as follows.

5th June 2010 *(Figure 8.2.3)*: the NAH is well-developed and there is a general anticlockwise air flow around it. A new low is developing over Newfoundland, and a mature one is SE of Greenland. The developing low effectively negates the wind to the S and W of it as well as giving a cyclonic patch directly over the N part of the Grand Banks (very tempting to mess around with spinnakers if one of these goes over. Avoid the temptation), while the mature low provides decent W winds across most of the great circle route to Derry.

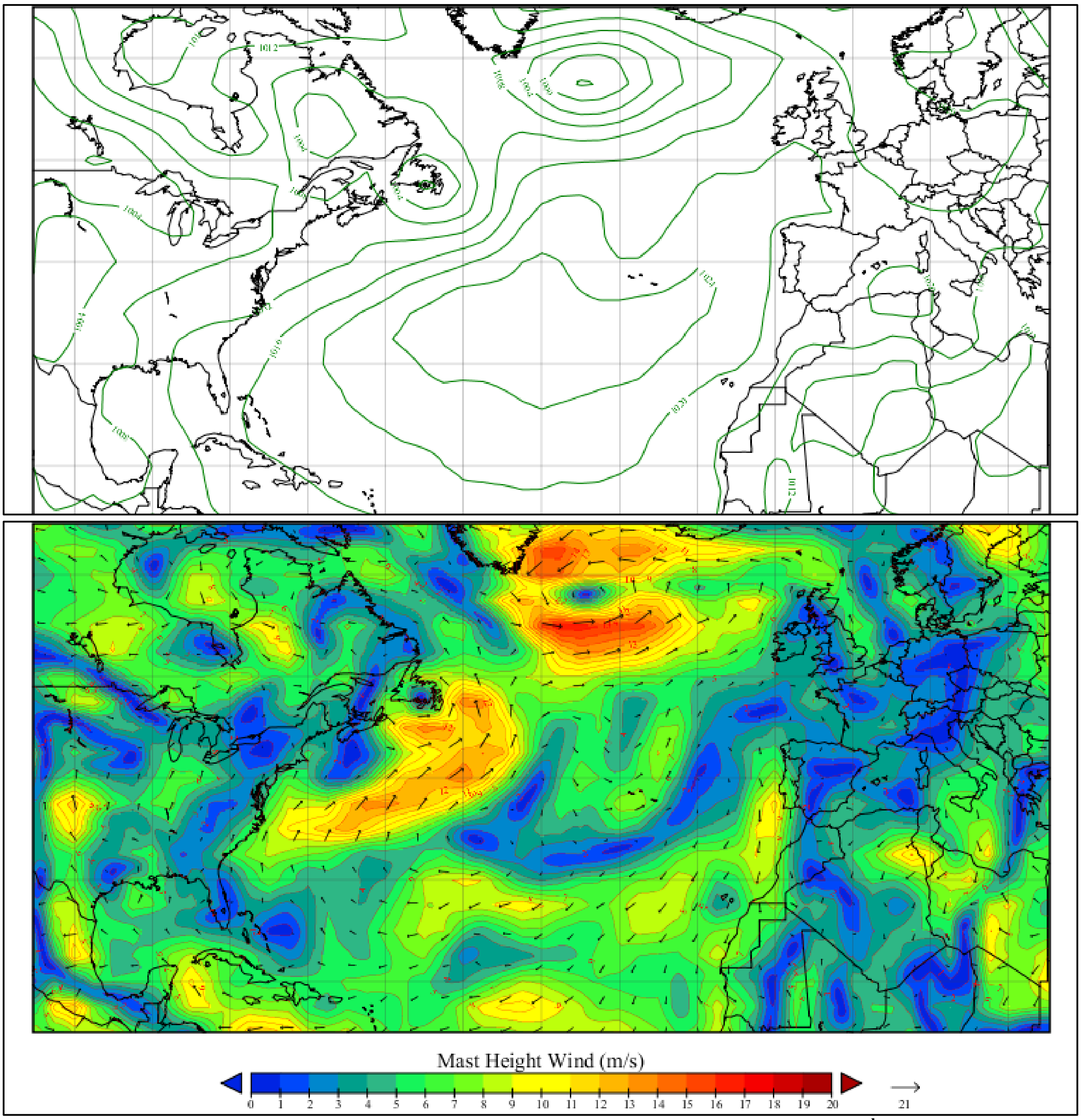


Fig 8.2.3: sea level pressure (top, hPa) and mast height winds (bottom, m/s) for 5th June 2010 (5)

7th June 2010 (*Figure 8.2.4)*: the two lows have moved further E, and the transition between them is important. The light wind band straddles the great circle route, and two yachts neck and neck but a mere 30’ apart in latitude will feel very different winds, with the southern one having the best of it. These conditions are perfect for the start, however, but will give a beat for the N of Ireland.

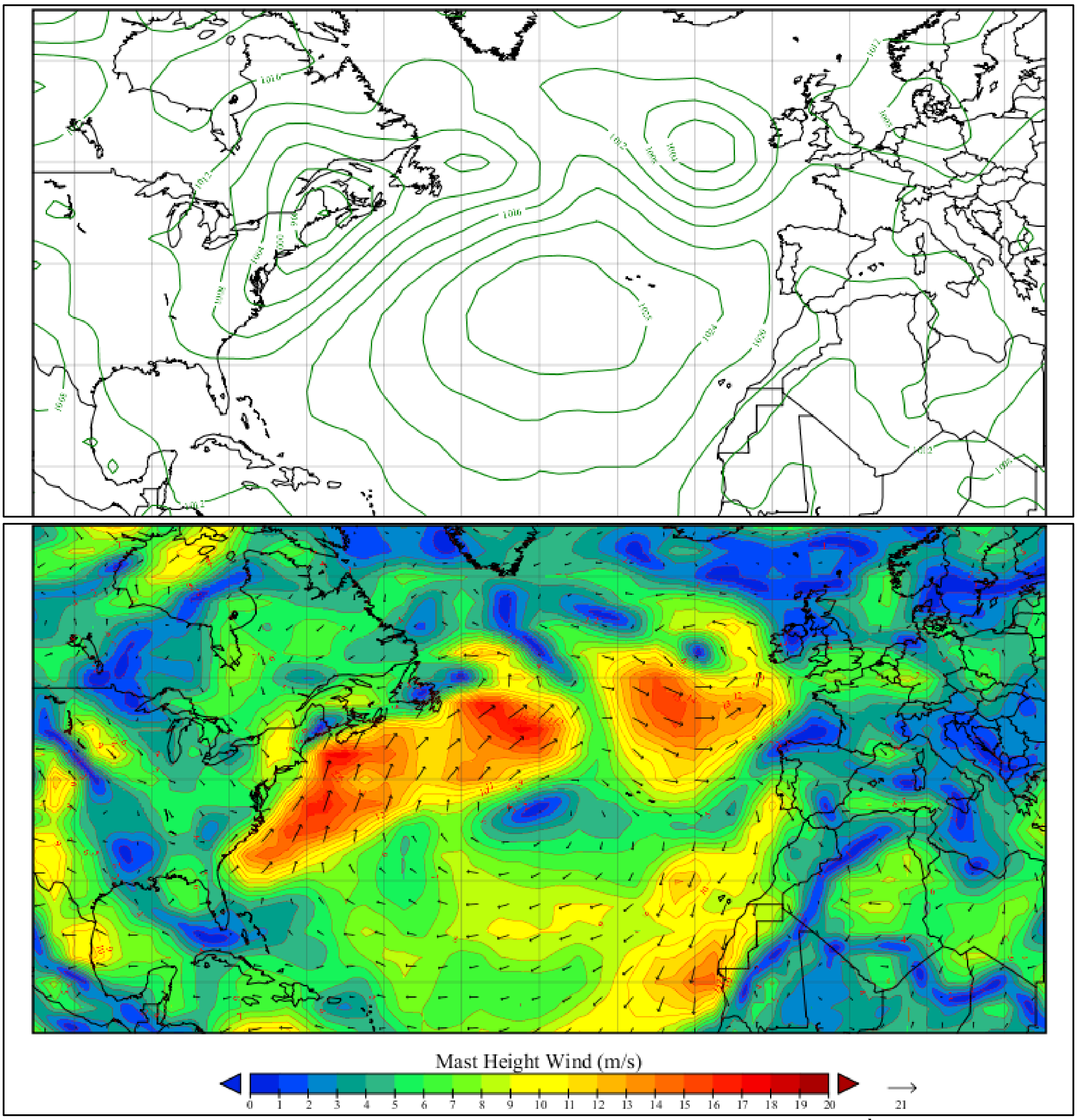


Fig 8.2.4: sea level pressure (top, hPa) and mast height winds (bottom, m/s) for 7th June 2010 (5)

10th June 2010 *(Figure 8.2.5)*: this is the classic North Atlantic blocking high, giving an enormous light wind strip straddling the route. Any yachts just squeezing past the N end of this before it crosses the route will get a massive advantage.

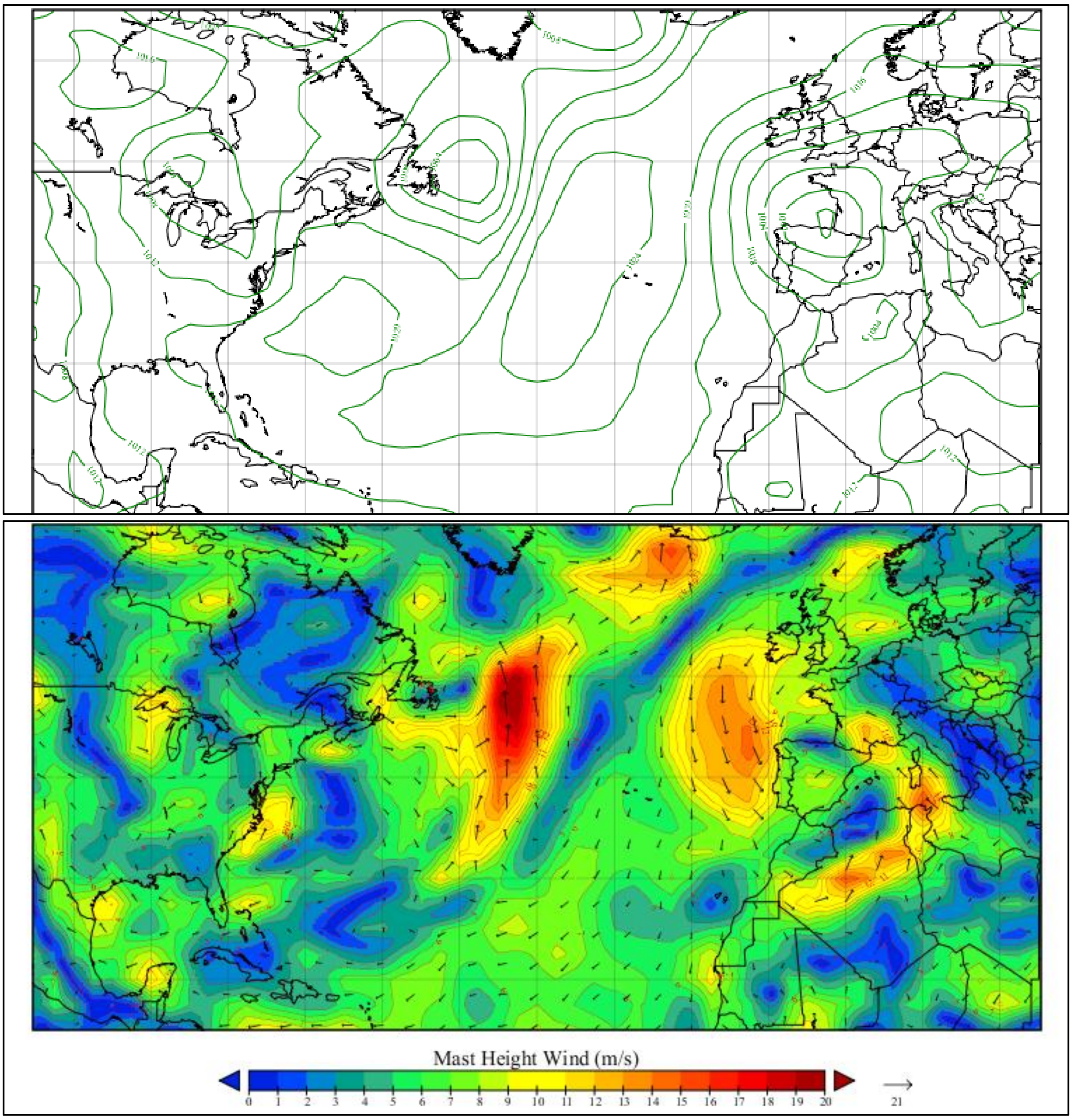


Fig 8.2.5: sea level pressure (top, hPa) and mast height winds (bottom, m/s) for 10th June 2010 (5)

The 500 hPa data is telling in this situation (*Figure 8.2.6).* The 5640 m contour at the 500 hPa level is an excellent proxy for the location of the Jet Stream. This in turn gives an idea of where the lows will go – generally just polewards of this, as shown by the sea level pressure plot. This 5640 m contour at 500 hPa is well forecast by various ensemble forecasting (*section A.5*) agencies, notably the US Fleet Numerical Meteorology and Oceanography Center (FNMOC) and the European Centre for Medium range Weather Forecasting (ECMWF).

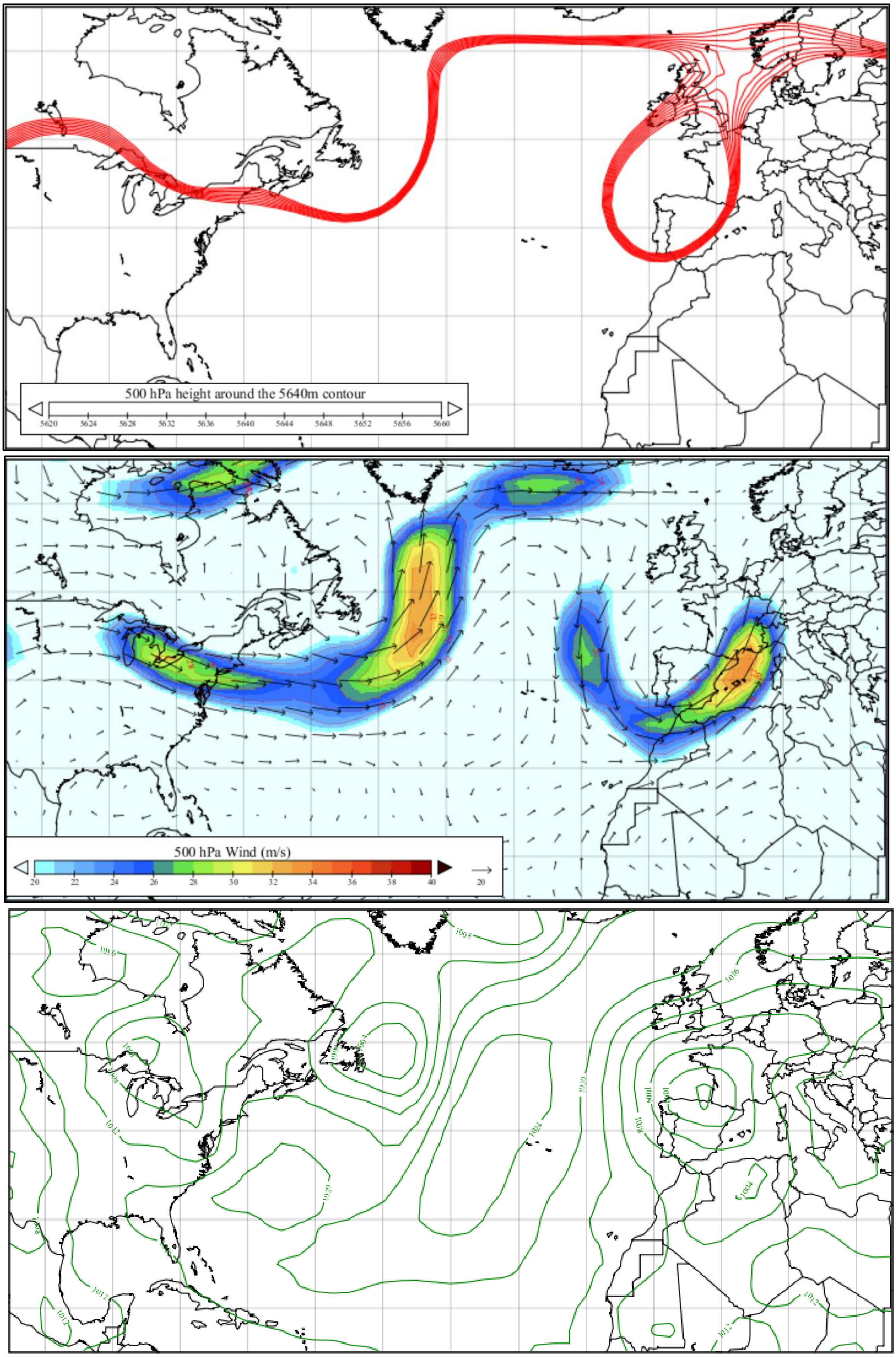


Fig 8.2.6: 500 hPa heights around the 5640m contour (top, m)
500 hPa winds (middle, m/s) and
sea level pressure (bottom, hPa) for 10th June 2010 (5)

8.3. Currents

From New York to the Flemish Cap is where this gets interesting, after that there is the general east going flow of the Gulf Stream over the Atlantic, and then once the continental shelf around the British Isles is reached the tidal effects become over-riding. From Nova Scotia going eastwards across the Grand Banks the cold Labrador Current comes southwards and then SW to meet the warmer Gulf Stream (*Figure 8.3.1)*. A close eye should be kept on SST, as it's really obvious when you go from the warm favourable flow to the cold contrary flow. The Cabot Strait has some strong localised currents, so if the route takes the fleet there the pilot books are recommended reading.

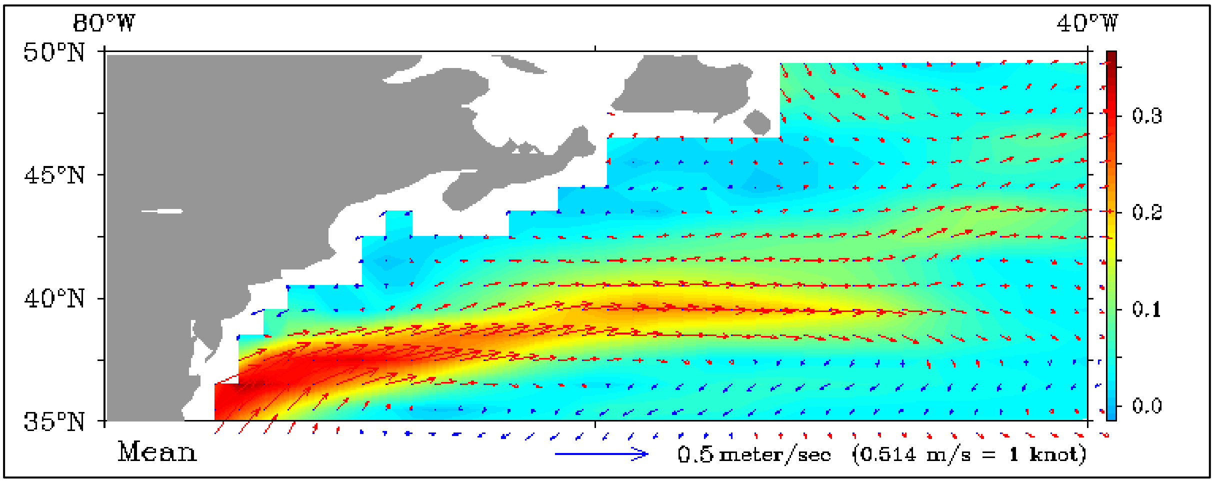


Fig 8.3.1: mean surface currents for June to August, 1993 to 2009 (m/s) (10)

This cold current can lead to persistent advection fog if the wind is from the SE to SW and bringing relatively warm, moist air in. The flow across the Atlantic after this is along the route *(Figure 8.3.2).*

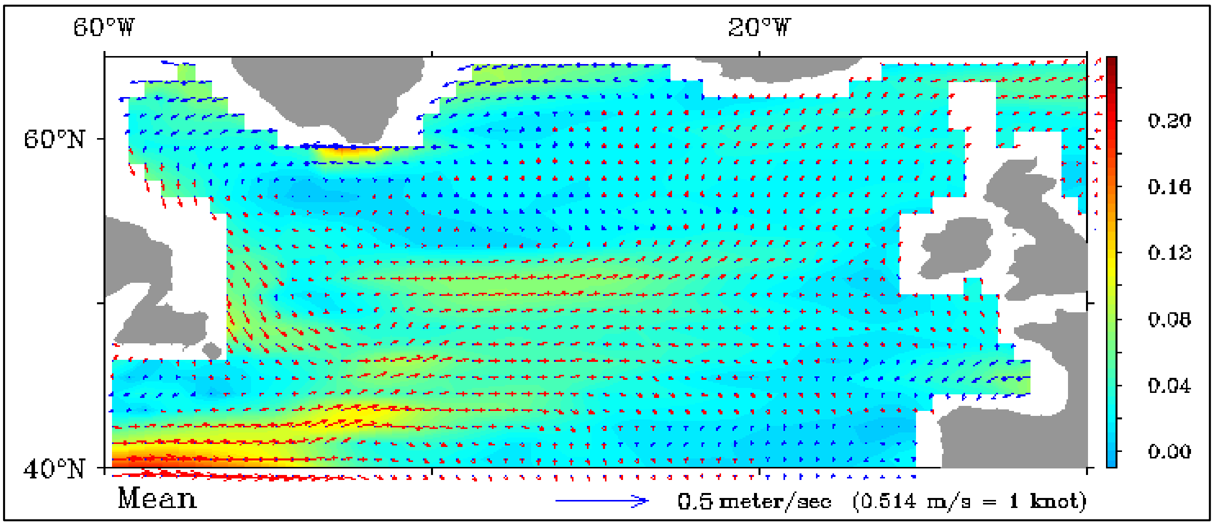


Fig 8.3.2: mean surface currents for June to August, 1993 to 2009 (m/s) (10)

A.1. Squalls

The first thing is to work out where they will move with respect to you, and during the day the Mark 1 eyeball is the best method to use. Simply treat any worrying squall cloud as if it was an approaching ship – if it is on a reasonably steady bearing and doesn't seem to be going to port or starboard of you then it will pass over you. Likewise, if it seems to be opening its bearing to pass ahead or astern of you then that is what it will do. At night a good radar watch should be kept, so make sure if you have it that you look at your set every quarter of an hour or so, it's a good reason to put the kettle on if nothing else. A visual watch is still effective at night of course, as an approaching squall will start to block out the otherwise bright stars. If you do pick one up on radar, put an Electronic Bearing Line (an EBL) on it and monitor it – if the squall marches straight down the line it is going to pass over you. At this point you may want to change course or reduce sail, or both!

Squalls are convective systems, driven by the strong solar radiation in the sub-tropics and tropics. They develop during the day and are seen well on thermal infra red images. The higher the cloud is the colder its top will be, and the whiter it will appear on the thermal infra-red (TIR) image. This is shown (*Figure A.1.1),* as the convection increases to a peak and then rapidly drops off. The worst squalls for sailing are the ones that grow in front and over the boat, and suddenly seem to sit there with no wind in the middle of them, leaving you just bobbing around until the squall slowly moves off. These are also the ones that stay during the night as well, which seems to go against the fact that convection is kicked off by solar radiation warming the surface.

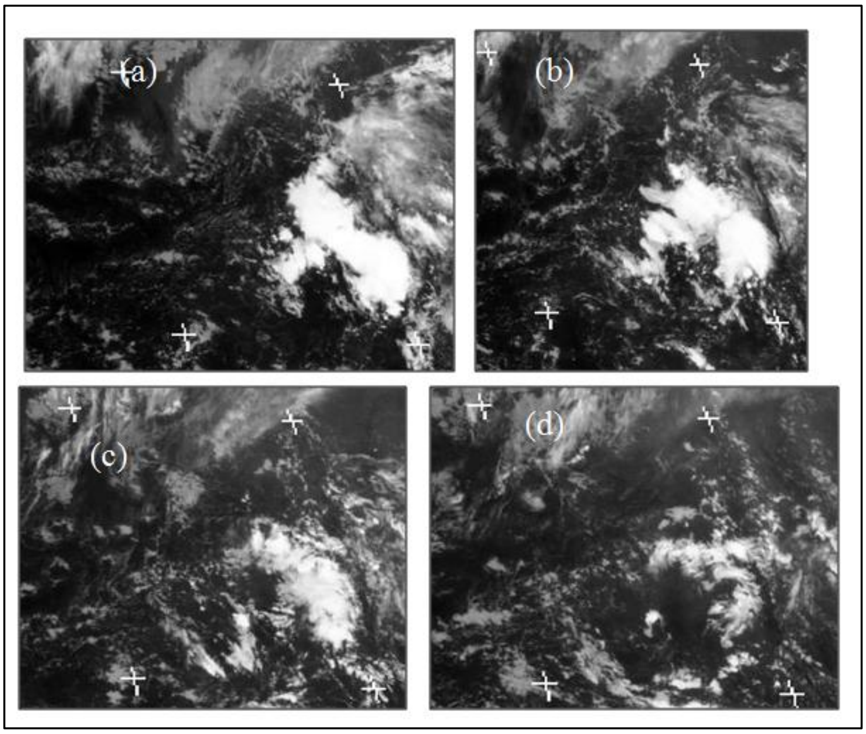


Fig A.1.1: TIR images of Tropical Atlantic Squalls at 3 hourly intervals

Let's look at a simple squall to start with. If there is no gradient wind, a convective system will effectively kill itself off (*Figure A.1.2).* Warm air will rise to start with and as it is over the ocean it will be moist. As this rises it cools, and the water will start to condense to form clouds. The cloud droplets will increase in size until their weight exceeds the upward force of the updraft and they will fall as rain. As the rising air reaches the top of the squall cloud it will have been cooled more than the surrounding air due to the energy taken out by the water condensing and so this air will fall down the outside of the cloud and some inside it as cold downdrafts, which is what you often feel just before a squall actually passes over you. Also the raindrops themselves will drag air down with them, causing further downdrafts inside the cloud. This eventually counteracts the updraft of warm air, and the squall just peters out, with the cloud base getting higher and higher until it disappears.

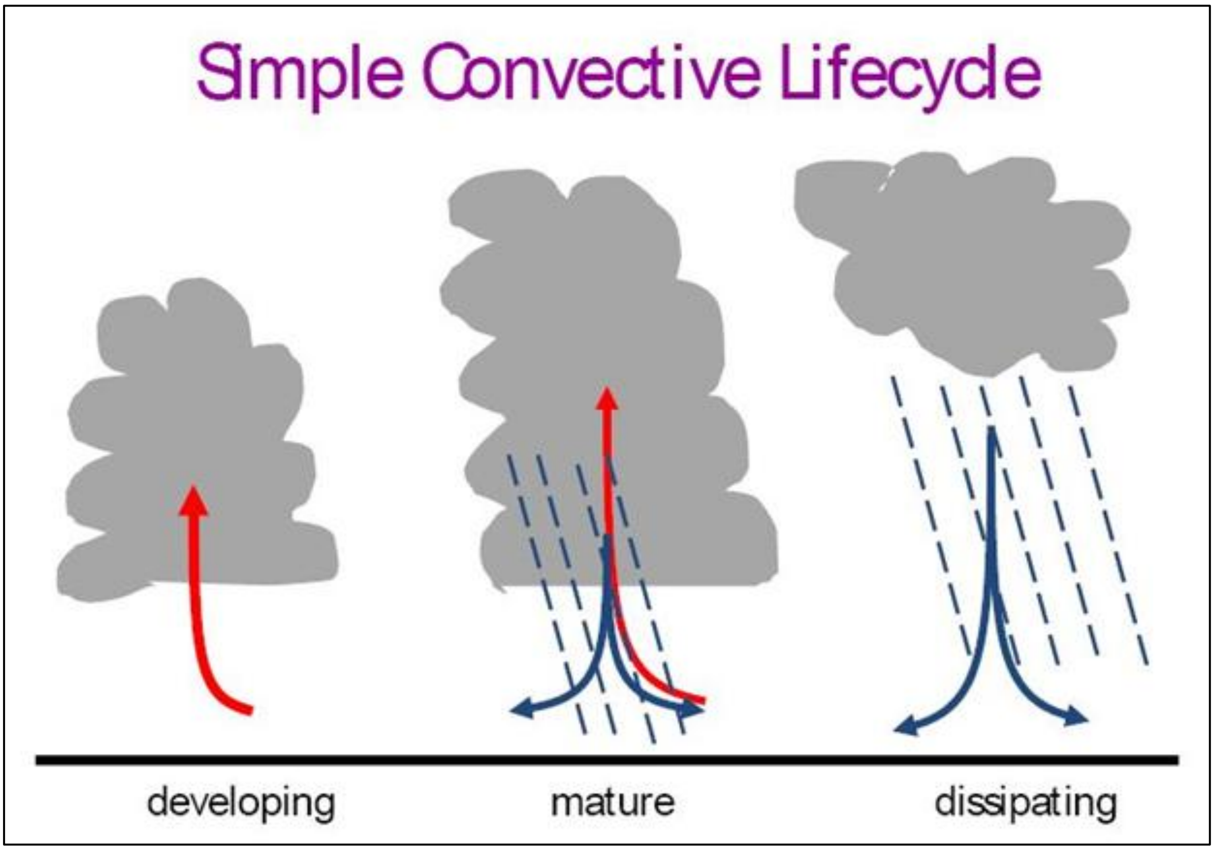


Fig A.1.2: the rise and fall of a simple squall

However, if there is a steady wind blowing this will give wind shear, the phenomenon whereby surface friction slows the surface wind down and it increases in speed with altitude until the steady gradient wind speed is reached. This is the situation which will give rise to self-sustaining squalls (*Figure A.1.3).* The wind shear makes the whole convective system lean over, which then make the precipitation and therefore the cold downdrafts fall away from the warm thermal updrafts. As these cold downdrafts hit the surface, they spread out in all directions, including against the regional wind. As the cold downdrafts are denser than the surface air they will actually force this warmer air to rise (shown by the purple line) and this process will carry on at night – the system is effectively generating its own lifting mechanism. Also, if the velocity of the downdraft as it spreads out over the surface is the same as that of the regional wind, the system will effectively stay at the same place – and if that's directly above your boat, you have no choice but to bob around until it slowly moves off.

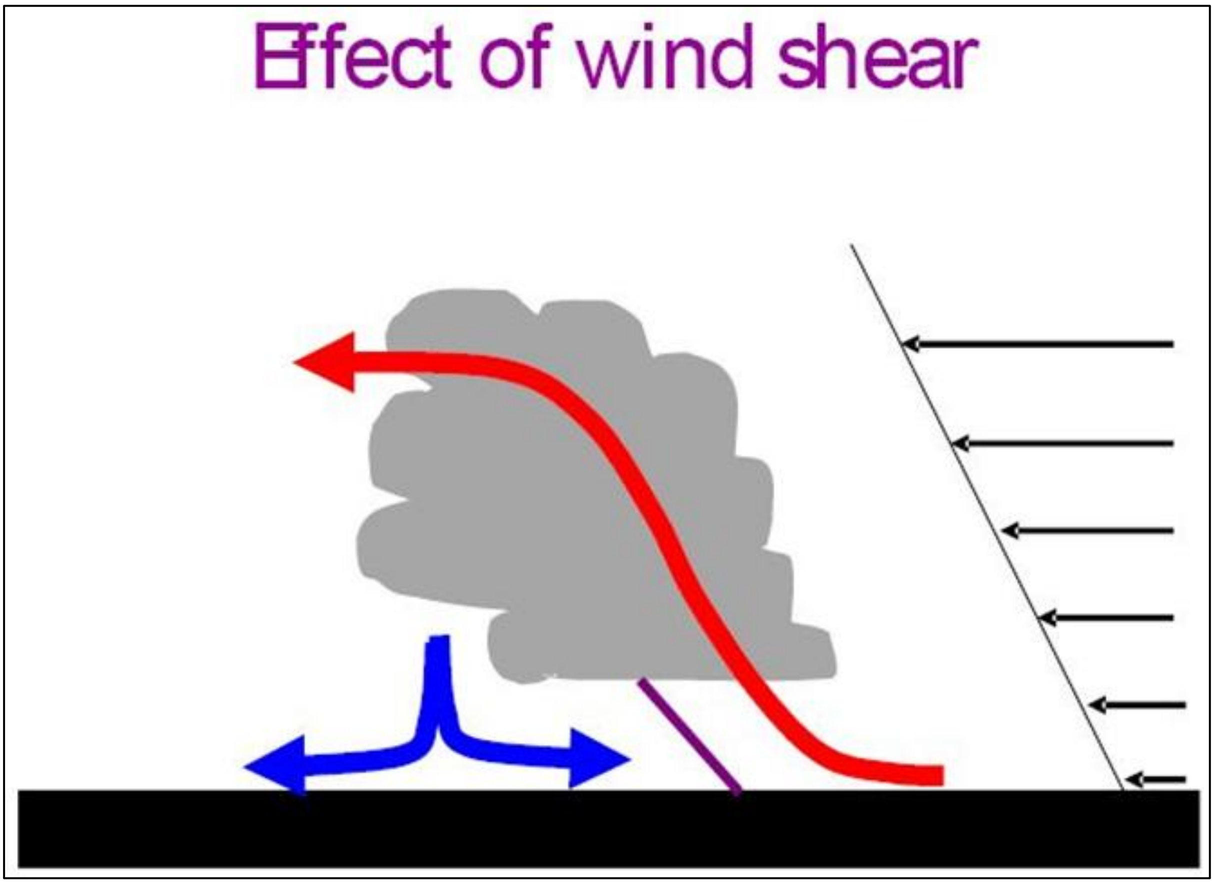


Fig A.1.3: a self-sustaining squall

The squall will also have a localised effect on the general gradient wind (*Figure A.1.4).* If the squall is directly coming at you, the gusts will add to the gradient wind, increasing the wind you feel, if it passes ahead of you the gusts will act against the gradient wind, decreasing or sometimes even reversing it. If the squall passes to the side of you then depending on the spatial relationship it will back or veer the wind – the example shows a typical North East Trade Wind squall with the wind veering if the squall passes south of you, backing if it passes north of you.

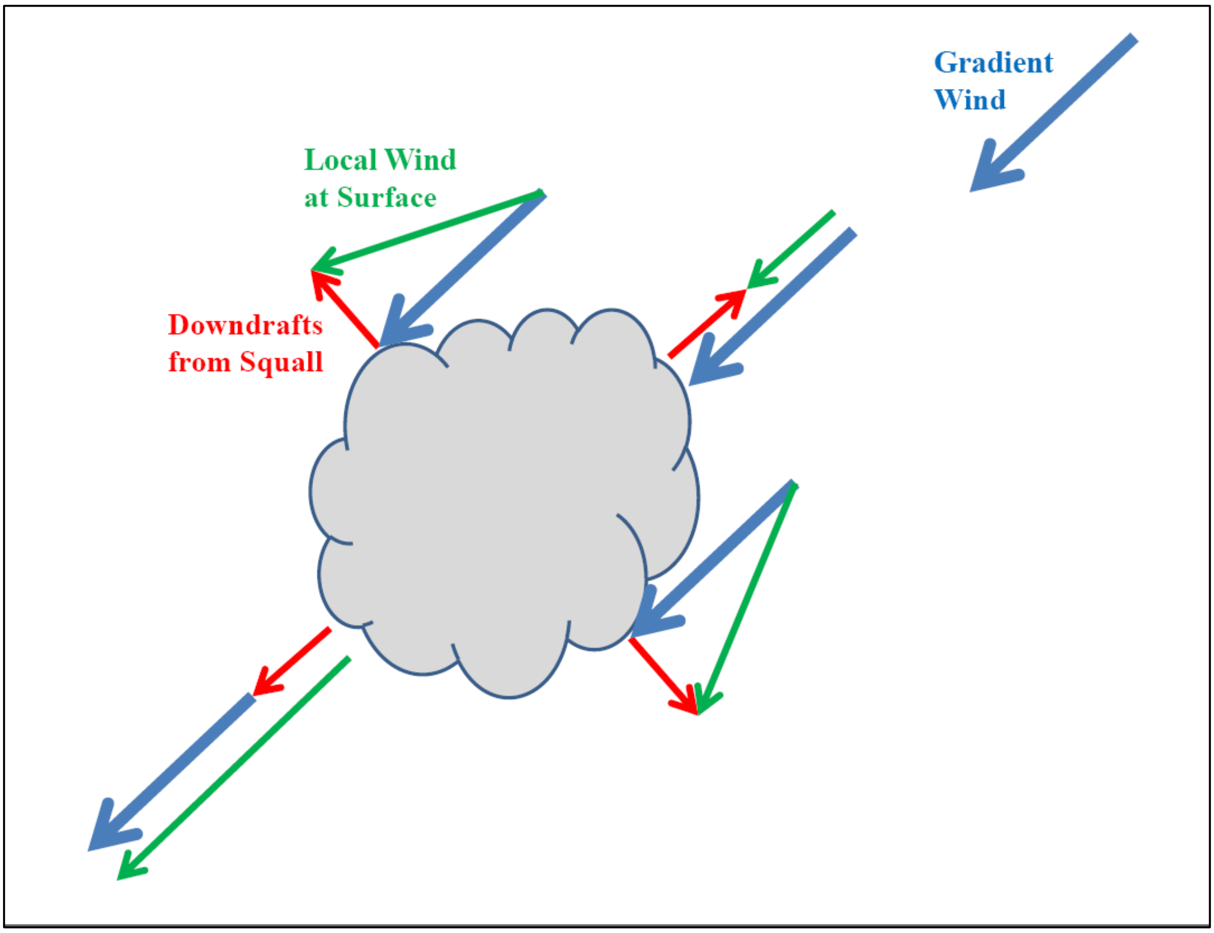


Fig A.1.4: the effect of squall gusts on surface winds around the squall

A.2. The Ocean High Pressure Systems – How are they Formed?

We are familiar with weather forecasters talking about “the North Atlantic high”, or “the Azores high”, and there are similar highs in all the major oceans at about 30^{O} to 40^{O} north and south of the Equator. The idea of a polar high makes sense as the temperature is colder there and so the air will be more dense, but that’s not the case here. As with most things meteorological, it comes down to the way the Sun heats the Earth. As we discussed earlier, the Equatorial regions receive more heat than the polar ones, and in fact they have more solar radiation coming in than surface radiation going out – there is a net heating effect. This would imply that there is an extra factor removing heat, as otherwise the temperature would just continue to rise. The part of the Earth directly under the sun is hottest, and therefore will heat the air above it causing convection and vertical motion – this is why the equator (plus or minus about 10 degrees depending on the season) has a relatively stable belt of low pressure around it. This vertically rising air must go somewhere, and it diverges north and south at the top of the troposphere. Looking just at the tropical North Atlantic part, this vertical and then north-going air removes heat from the equatorial region. Generally the heat radiating from the surface reduces the further north you are as the surface temperatures cool, and by about 30^{O}N this is equal to the heat coming from the sun for the same surface area – at this point the upper level air cannot keep going north as it would have to generate its own energy (a physical impossibility) and so the only place it can go is down. As air is converging at altitude it has to diverge at the surface – and this is what we see as a high pressure system. This diverging air at the surface goes back towards the low pressure belt beneath the sun, and this gives us our basic tropical circulation, called the Hadley Cell (*Figure A.2.1).* As you can see, the down-going air is strongest in winter, which means that the Hadley Cell in the North Atlantic is strongest in winter – which is when the Trade Winds blow. Due to the Earth’s rotation and therefore the Coriolis effect the surface winds, the Trades, coming back from the surface high towards the Equator do not blow from the north, but from the north-east, veering to the east the further west you go, and these give the ideal winds to travel from Europe across the Atlantic.

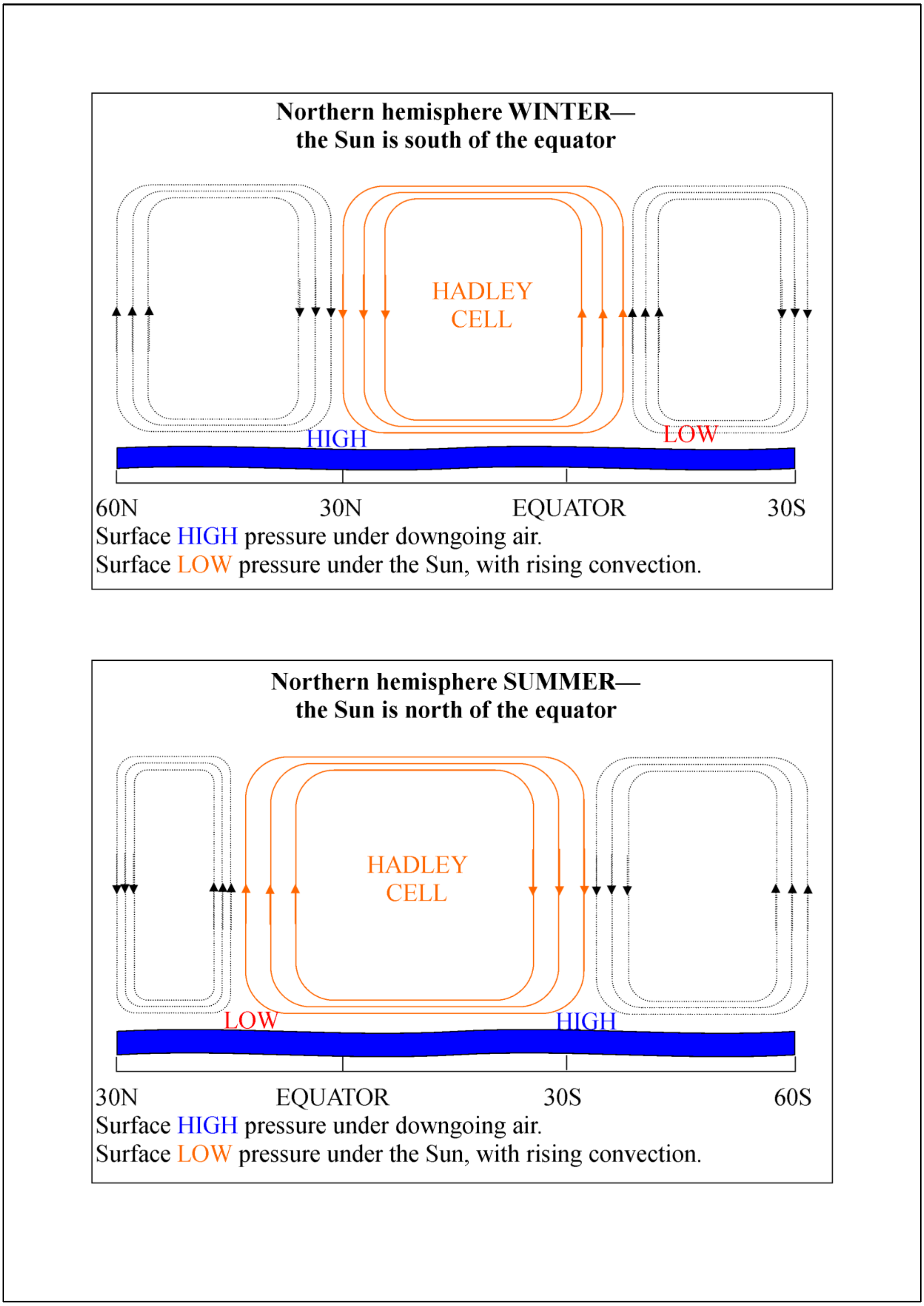


Fig A.2.1: a schematic of the Atlantic Ocean's high pressure systems

An idealised representation of this shows us the overall global pressure and wind conditions (*Figure A.2.2).*

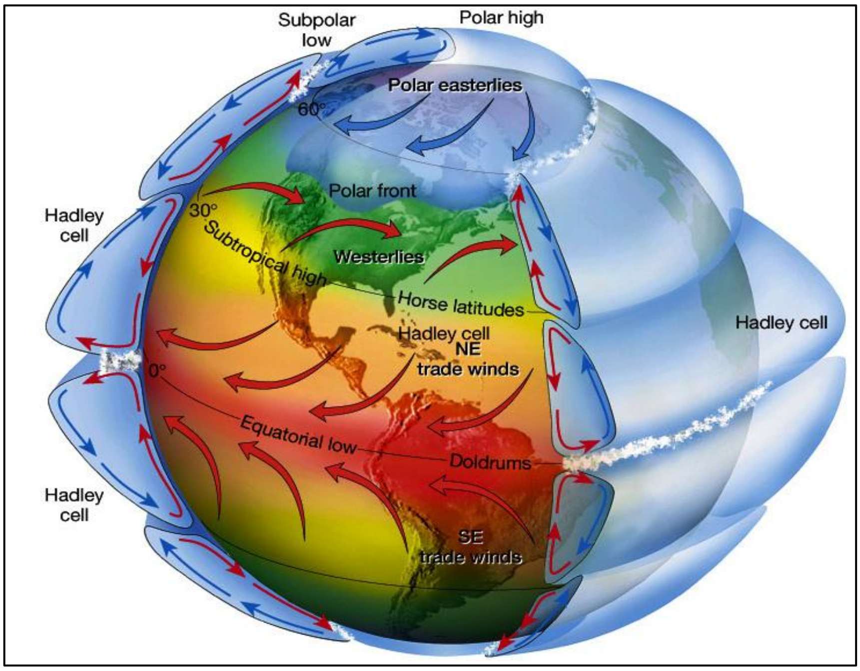


Fig A.2.2: an idealised representation of the global circulation conditions (8)

The actual global average is complicated by land masses, and the effect of the globally continuous Southern Ocean is very visible *(Figure A.2.3)*, giving a very low pressure band encircling the southern hemisphere just north of Antarctica.

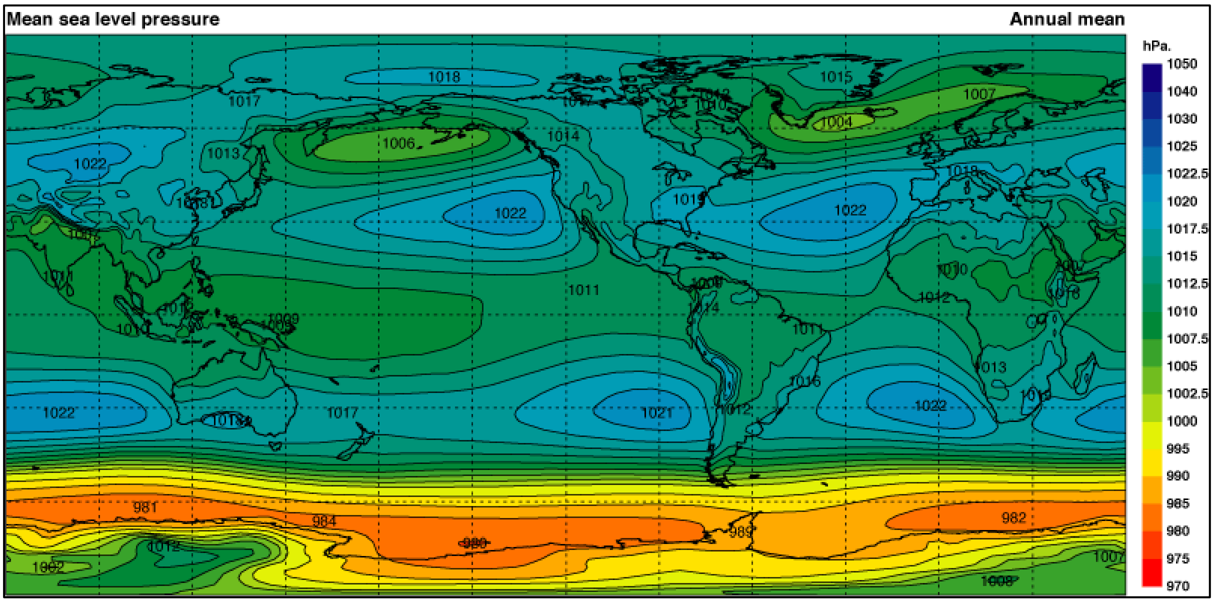


Fig A.2.3: annual average of sea level pressure (29)

A.3. Diurnal Variation

As you get to within about 30^{O} of the Equator the barometer will start to exhibit a twice daily rise and fall on top of the changes due to the low and high pressure systems. These small changes (up to ± 3 or 4 hPa at most) are masked by the general weather in the higher latitudes, but the more settled pressure regime of the Tropics allows them to be seen. The times of local maximum pressure are usually 1000 and 2200 local time, and minimums are at 1600 and 0400 local time, and the relevant Pilot Book will give the amount of the correction.

The timing of this is the clue to its cause – it happens 2 hours ahead of local noon. The Sun's radiation is short wave, and as such not absorbed much at all by the troposphere. However, the thermosphere, the very outer layer of the atmosphere, is warmed up by the Sun and so expands. The expanding air cannot go to the east, as that has already been warmed, and so goes west. This means that there is physically a little more air above the ground just ahead of the Sun, which means there is a slightly higher pressure (no more than 4 hPa in 1000 hPa) ahead of the Sun, at 1000 local time (*Figure A.3.1).* This sets up a wave which has two wavelengths around the globe, hence another maximum 12 hours later (or earlier, depending on how you look at it) with minimums in between.

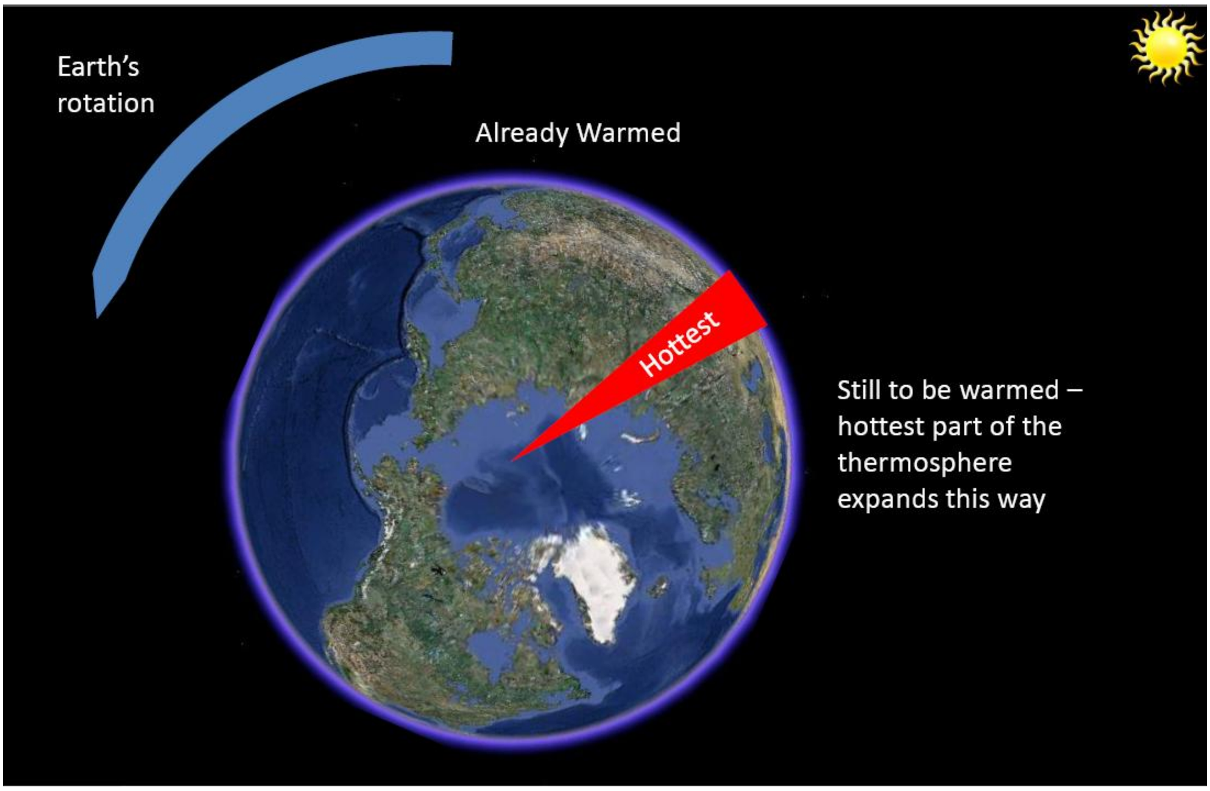


Fig A.3.1: diurnal variation

A.4. The El Nino Southern Oscillation

This entirely natural oscillation is well described in the following article reproduced from the NOAA website (http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html). The very small but important diagram that explains the whole thing is expanded here (*Figure A.4.1*).

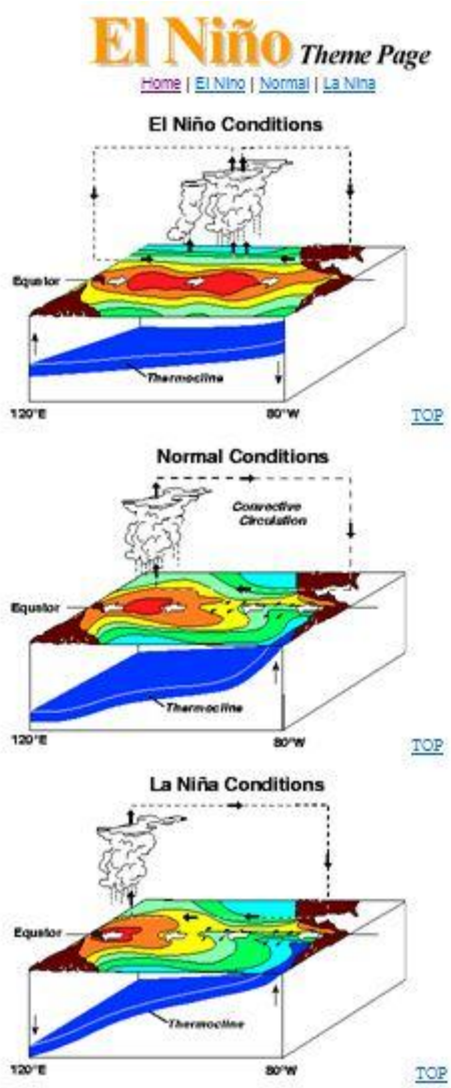
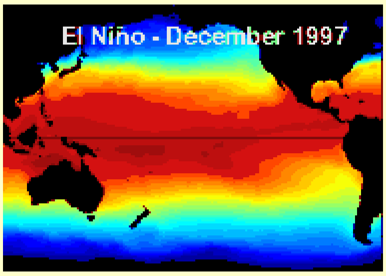


Fig A.4.1: diagram showing how the change in SST distribution affects convection activity over the central Pacific during El Nino and La Nina episodes (NOAA)

El Niño is characterized by unusually warm ocean temperatures in the Equatorial Pacific, as opposed to La Niña, which characterized by unusually cold ocean temperatures in the Equatorial Pacific. El Niño is an oscillation of the ocean-atmosphere system in the tropical Pacific having important consequences for weather around the globe.



Among these consequences are increased rainfall across the southern tier of the US and in Peru, which has caused destructive flooding, and drought in the West Pacific, sometimes associated with devastating brush fires in Australia. Observations of conditions in the tropical Pacific are considered essential for the prediction of short term (a few months to 1 year) climate variations.

To provide necessary data, NOAA operates a network of buoys which measure temperature, currents and winds in the equatorial band. These buoys daily transmit data which are available to researchers and forecasters around the world in real time.

In normal, non-El Niño conditions (top panel of schematic diagram), the trade winds blow towards the west across the tropical Pacific. These winds pile up warm surface water in the west Pacific, so that the sea surface is about 1/2 meter higher at Indonesia than at Ecuador.

Read more on:

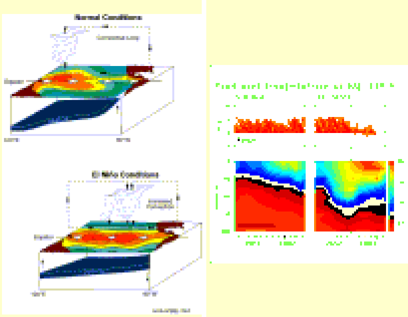
- Recognizing an El Niño
- El Niño animations
- Recent El Niños
- Selected references

Related sites:

- What is La Niña?
- Children of the Tropics: El Niño and La Niña.
- Today's El Niño and La Niña information ***Updated daily!***
- Sites in Spanish and Portuguese language

Click for full size image

(will open a new browser window)



(a) **(b)**

(a) Schematic diagram of normal El Niño conditions in the Pacific Ocean, and (b) temperature on the Equator at 110W

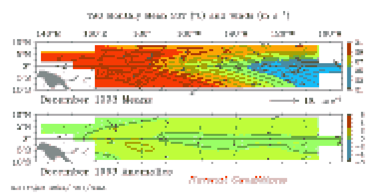
The sea surface temperature is about 8 degrees C higher in the west, with cool temperatures off South America, due to an upwelling of cold water from deeper levels. This cold water is nutrient-rich, supporting high levels of primary productivity, diverse marine ecosystems, and major fisheries. Rainfall is found in rising air over the warmest water, and the east Pacific is relatively dry. The observations at 110 W (left diagram of 110 W conditions) show that the cool water (below about 17 degrees C, the black band in these plots) is within 50m of the surface.

During El Niño (bottom panel of the schematic diagram), the trade winds relax in the central and western Pacific leading to a depression of the thermocline in the eastern Pacific, and an elevation of the thermocline in the west. The observations at 110W show, for example, that during 1982-1983, the 17-degree isotherm dropped to about 150m depth. This reduced the efficiency of upwelling to cool the surface and cut off the supply of nutrient rich thermocline water to the euphotic zone. The result was a rise in sea surface temperature and a drastic decline in primary productivity, the latter of which adversely affected higher trophic levels of the food chain, including commercial fisheries in this region. The weakening of easterly tradewinds during El Niño is evident in this figure as well. Rainfall follows the warm water eastward, with associated flooding in Peru and drought in Indonesia and Australia. The eastward displacement of the atmospheric heat source overlaying the warmest water results in large changes in the global atmospheric circulation, which in turn force changes in weather in regions far removed from the tropical Pacific.

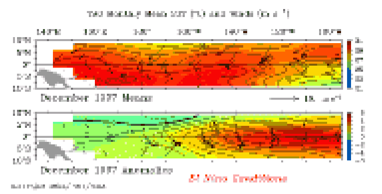
Recognizing El Niño

El Niño can be seen in Sea Surface Temperature in the Equatorial Pacific Ocean

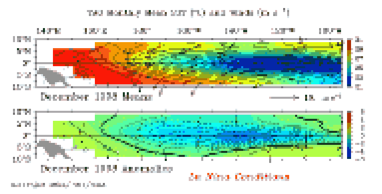
El Niño can be seen in measurements of the sea surface temperature, such as those shown above, which were made from the TAO Array of moored buoys. In December 1993, the sea surface temperatures and the winds were near normal, with warm water in the Western Pacific Ocean (in red on the top panel of December 1993 plot), and cool water, called the "cold tongue" in the Eastern Pacific Ocean (in green on the top panel of the December 1993 plot). The winds in the Western Pacific are very weak (see the arrows pointing in the direction the wind is blowing towards), and the winds in the Eastern Pacific are blowing towards the west (towards Indonesia). The bottom panel of the December 1993 plot shows anomalies, the way the sea surface temperature and wind differs from a normal December. In this plot, the anomalies are very small (yellow/green), indicating a normal December. December 1997 was near the peak of a strong El Niño year. In December 1997, the warm water (red in the top panel of the December 1997 plot) has spread from the western Pacific Ocean towards the east (in the direction of South America), the "cold tongue" (green colour in the top panel of the December 1997 plot) has weakened, and the winds in the western Pacific, usually weak, are blowing strongly towards the east, pushing the warm water eastward. The anomalies show clearly that the water in the centre of Pacific Ocean is much warmer (red) than in a normal December.



Normal Conditions - December 1993



El Niño (warm) Conditions - December 1997



La Niña (cold) Conditions - December 1998

Also see the entire Pacific Ocean

December 1998 was a strong La Niña (cold) event. The cold tongue (blue) is cooler than usual by about 3° Centigrade. The cold La Niña events sometimes (but not always) follow El Niño events.

Animation of El Niño

Animation of physical processes allow scientists to better understand El Niño

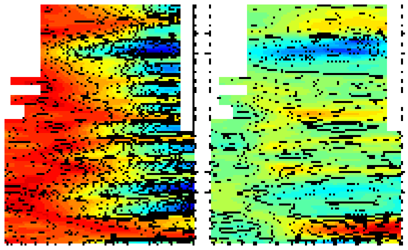
If you have an MPEG animation viewer, and sufficient memory, you can view an animation of El Niño which shows the changes in monthly sea surface temperature in the tropical Pacific Ocean. The animation is about 1 Megabyte in size. As you view this animation, you will see the warm water spreading from the western Pacific to the eastern Pacific during 1997. The bottom panel in the animation, labelled anomalies, shows how much the sea surface temperature for each month is different from the long term average for that month. The red colour in the anomalies plot indicates that the temperature of the water is much warmer than is normal for that month. Blue colour indicates that the water is much cooler than is normal for that month

Recent El Niños

Several recent El Niños can be seen in Pacific Sea Surface Temperature representations

Click for full size image

(will open a new browser window)



Mean and anomalies of sea surface temperature from 1986 to the present, showing El Niños in 1986-1987, 1991-1992, 1993, 1994 and 1997

In the left hand panel, you see the sea surface temperature at the Equator in the Pacific Ocean (Indonesia is towards the left, South America is towards the right). Time is increasing downwards from 1986 at the top of the plot, to the present, at the bottom of the plot. The first thing to note is the blue "scallops" on the right of the plot, in the eastern Pacific. These indicate the cool water typically observed in the Eastern Pacific (called the "cold tongue"). Cold tongue temperatures vary seasonally, being warmest in the northern hemisphere springtime and coolest in the northern hemisphere fall. The red colour on the left is the warm pool of water typically observed in the western Pacific Ocean. El Niño is an exaggeration of the usual seasonal cycle. During the El Niño in 1986-1987, you can see the warm water (red) penetrating eastward in the Spring of 1987. There is another El Niño in 1991-1992, and you can see the warm water penetrating towards the east in the northern hemisphere spring of 1992. The El Niño in 1997-1998 is a very strong El Niño. El Niño years are easier to see in the anomalies on the right hand panel. The anomalies show how much the sea surface temperature is different from the usual value for each month. Water temperatures significantly warmer than the norm are shown in red, and water temperatures cooler than the norm are shown in blue.

Information on the names El Niño and La Niña

El Niño was originally recognized by fisherman off the coast of South America as the appearance of unusually warm water in the Pacific ocean, occurring near the beginning of the year. El Niño means The Little Boy or Christ child in Spanish. This name was used for the tendency of the phenomenon to arrive around Christmas.

In the right-hand plot of sea surface temperature anomalies, it is very easy to see El Niños, with water warmer than usual (red) in the eastern Pacific, during in 1986-1987, 1991-1992, 1993, 1994 and 1997-1998. Notice the very cool water (blue), in the Eastern Pacific, in 1988-1989. This is a strong La Niña, which occurs after some (but not all) El Niño years. 1995-1996 was a weaker La Niña year. It is unusual for El Niños to occur in such rapid succession, as has been the case during 1990-1994.

La Niña means The Little Girl. La Niña is sometimes called El Viejo, anti-El Niño, or simply "a cold event" or "a cold episode". El Niño is often called "a warm event".

There has been a confusing range of uses for the terms El Niño, La Niña and ENSO by both the scientific community and the general public, which is clarified in this web page on definitions of the terms ENSO, Southern Oscillation Index, El Niño and La Niña. Also interesting is the Web page: Where did the name El Niño come from?

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Credits and Acknowledgements | TAO Diagrams

A.5. Ensemble Forecasts

Ensemble forecasts are averages of many forecasts for the same time period done with slightly varying initial conditions – if the outcome is much the same for all of them it indicates a more stable atmospheric state, and thus a more likely forecast. Each of the individual forecasts is called an ensemble member, and you also have a control forecast, which is the one done with the standard initial conditions. FNMOC and ECMWF do the best publicly accessible ones, and they can give you an idea of the confidence of future forecasts. A really useful application is FNMOC's output for the position of the 500 hPa 5640 m height contour. This is a good approximation for the position of the Jet Stream, and also lows tend to be polewards of this, so it's a good indicator of where ocean highs will be (equatorwards of it). The example shown (*Figure A.5.1)* shows the likelihood of a ridge of high pressure W of Ireland on 4th May 2011. The colour scale denotes probability, so if the red 90% plus section is narrow then conditions are stable and it is a likely forecast. Don't forget with statistical forecasts though that there are lies, damn lies then statistics, and the probabilities here refer to the model outcomes – not necessarily to the weather itself, which generally doesn't care two hoots for statistics.

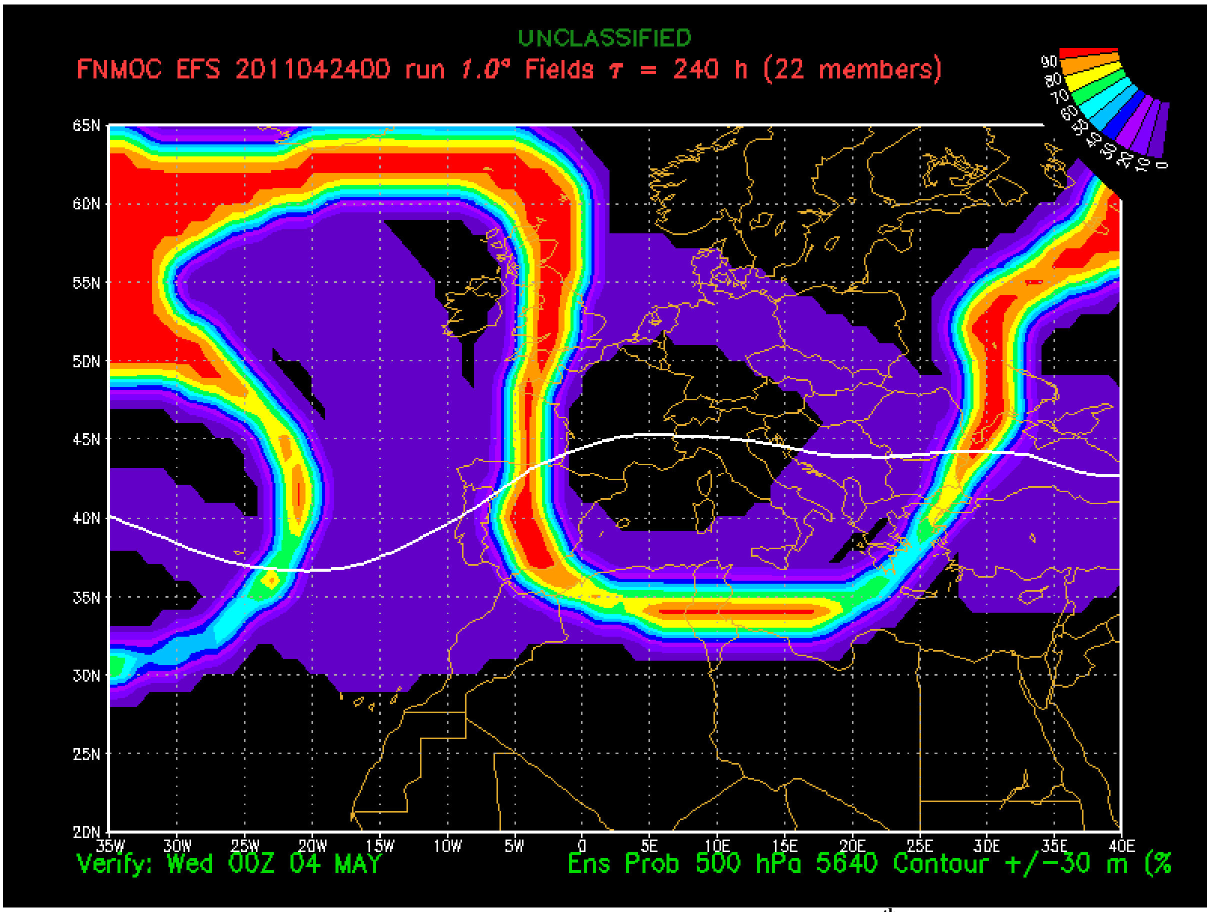

Fig A.5.1: ensemble forecast for the 500 hPa 5640 m contour for 4th May 2011 (14)

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