# ELEMENTI DI METEOROLOGIA PER LO SPORT DELLA VELA

# CORSO ATLETI ALTO LIVELLO
# CORSO ALLENATORI ALTO LIVELLO

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XV Zona - Online, 14 Gennaio 2022

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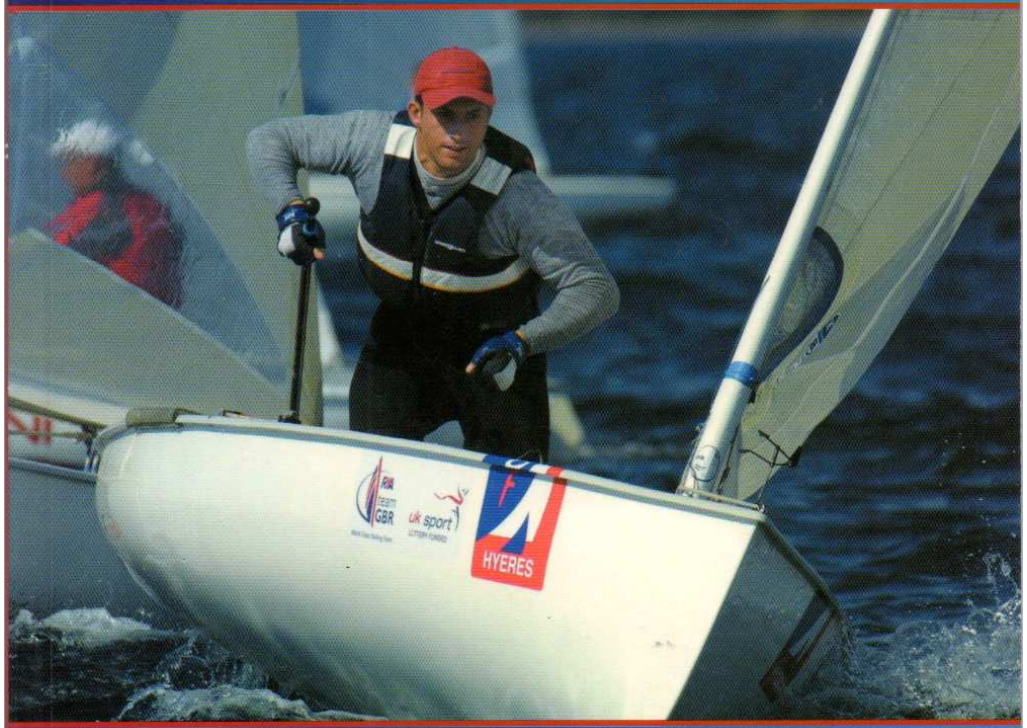
Lifeboats

# WIND STRATEGY

David Houghton &
Fiona Campbell

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# IL METEO PER LA VELA

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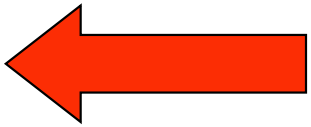
Nutrimenti mare

- Windy.com

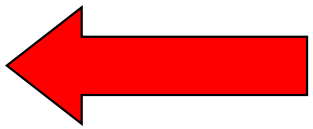


- Wind facts

- Winds near clouds

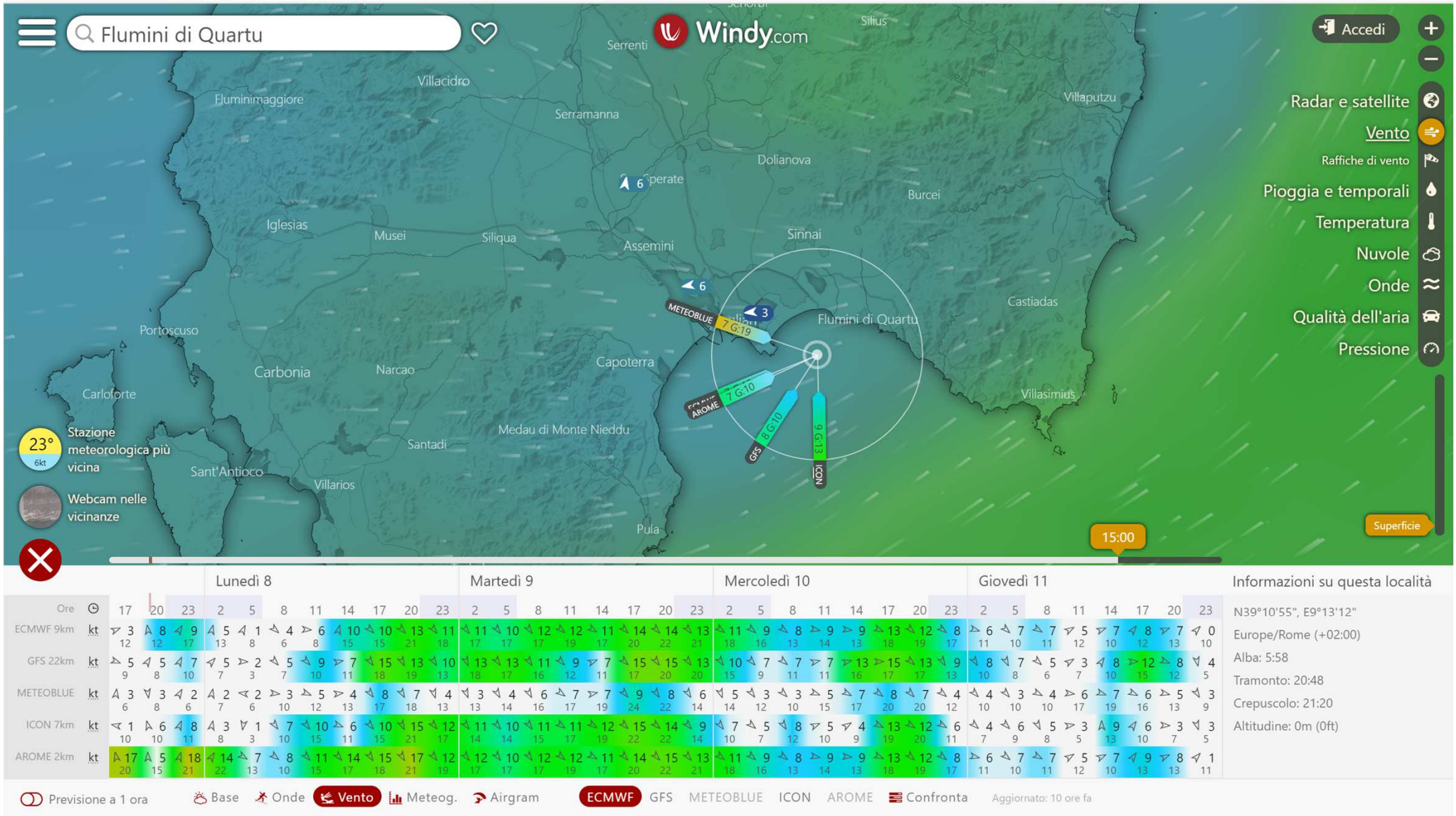
- Obstacles in the wind

- The oscillations



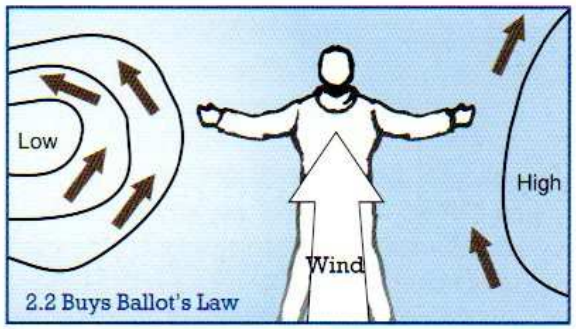
*Windy.com*

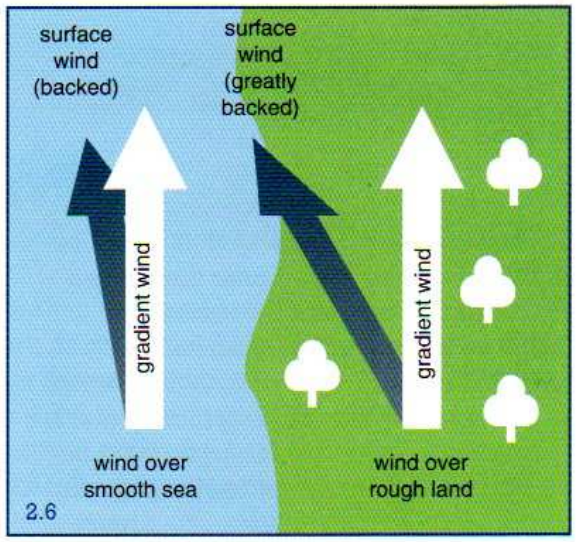
# Come funziona Windy.com?



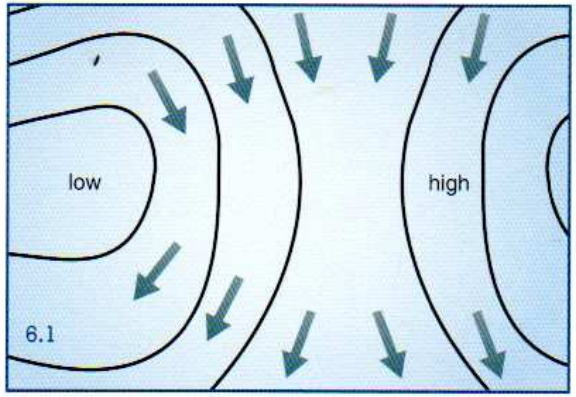
*Wind facts*

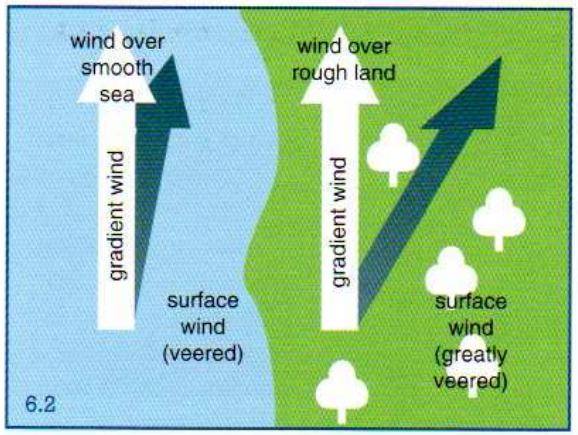
## *Northern Hemisphere*



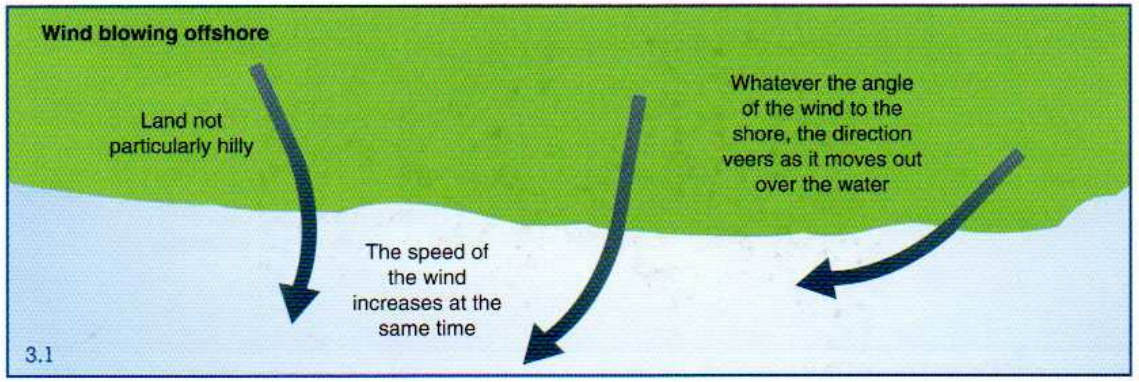




## *Southern Hemisphere*

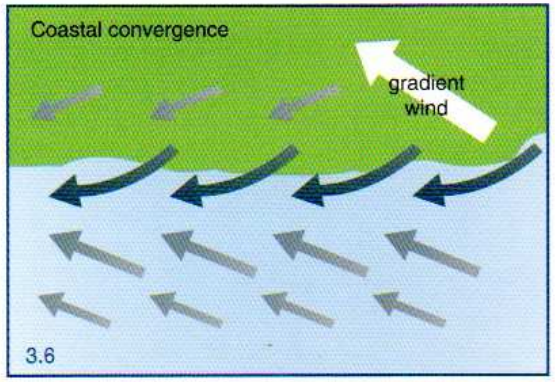


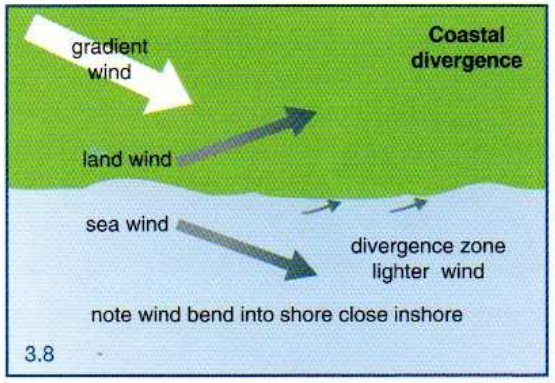
# *Northern Hemisphere: winds near coasts*



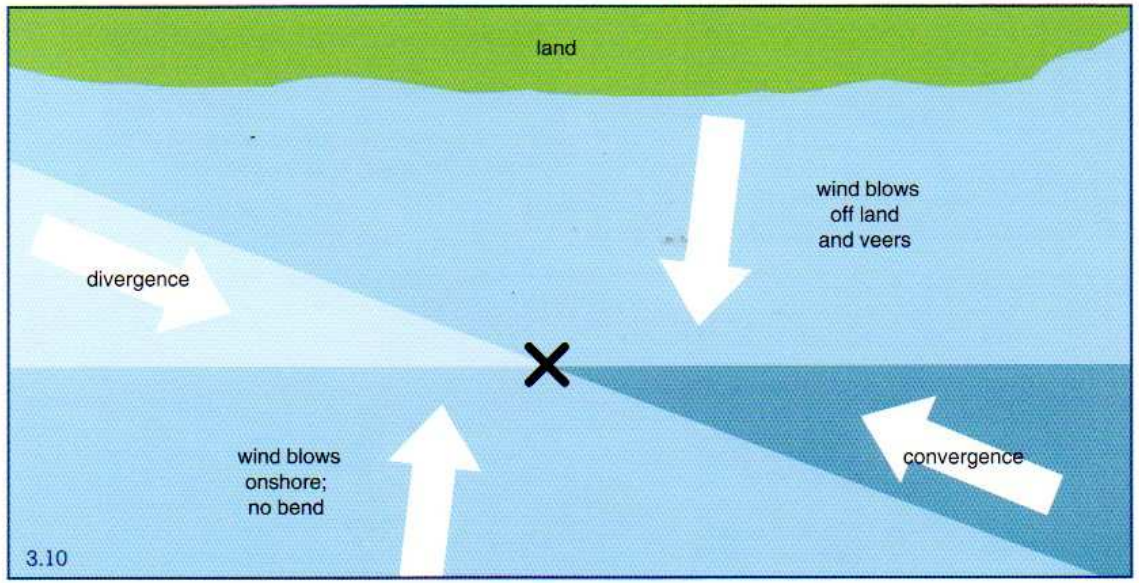

3.1 Above: with the wind blowing off the shore the wind veers and increases. On a gusty day the changes are most apparent in the lulls.



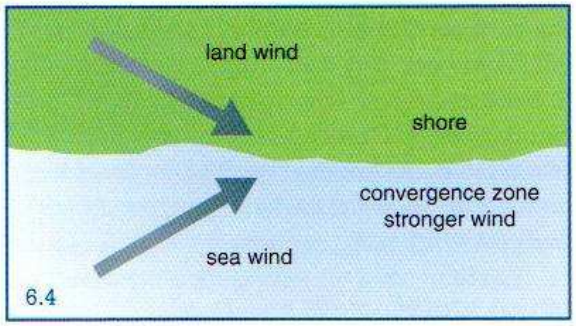

3.6 Above: with the wind blowing along the shore and the land up on your left (facing the wind) expect a band of up to 25% stronger wind 1-5 km offshore.

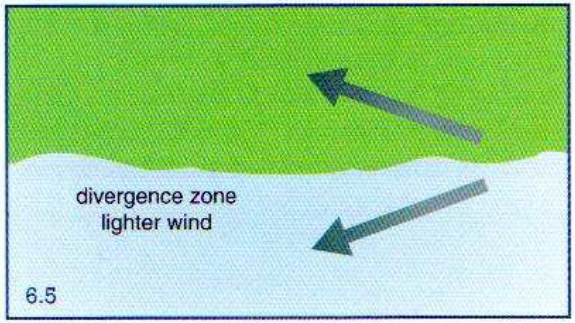


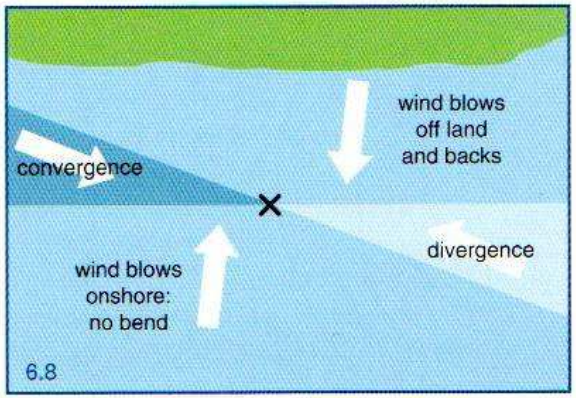

3.8 Above: with an alongshore wind and land on your right (facing the wind) expect lighter winds within 5 km of the shore, except on a sunny afternoon. Below: summary of costal effects on wind.



# *Southern Hemisphere: winds near coasts*



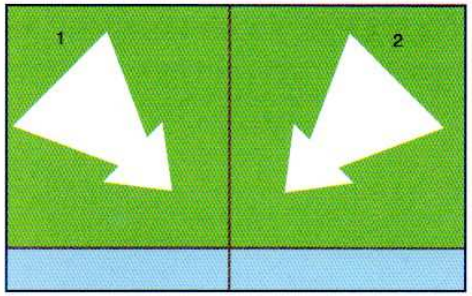



# Northern Hemisphere: the sea breeze with gradient wind

## The sea breeze

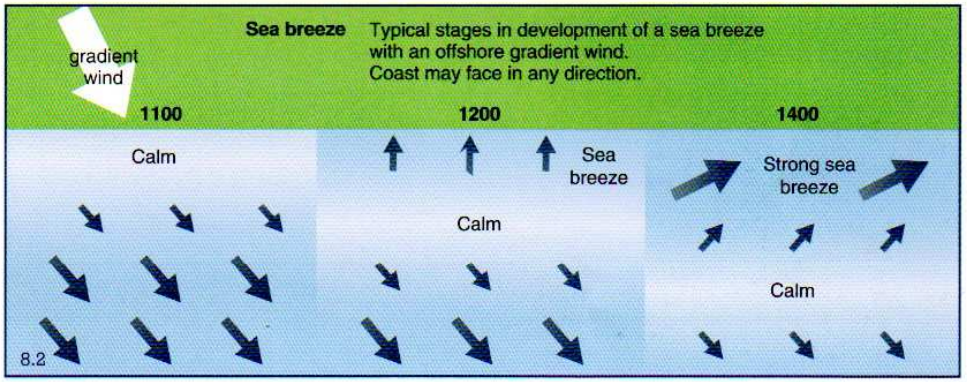
### Summary and signs

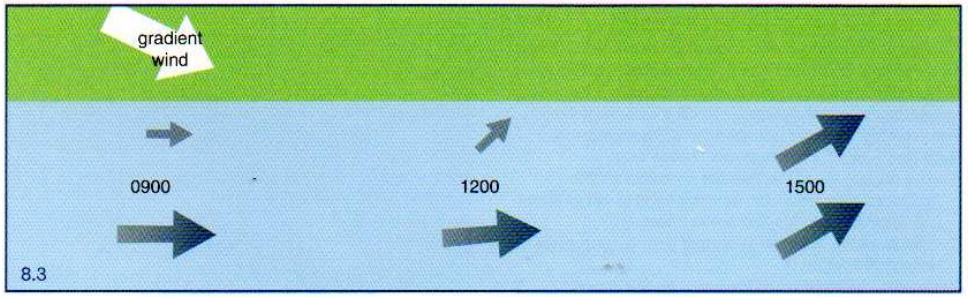
- Clear morning sky, or thin cloud.
- Temperature over land rises above sea temperature.
- Cloud offshore begins to dissolve.
- Initial offshore wind, if any, dies inshore.
- Gentle drift starts onto shore.
- Breeze builds and extends seawards, preceded by calm zone separating initial wind and sea breeze.
- Cloud over land, if any, more cumuliform.
- Breeze veers some 40 degrees in first hour then more slowly until 20 degrees back from shoreline.
- Strength increases; maximum Force 4 or 5 always near the shore.
- Breeze dies towards sunset.

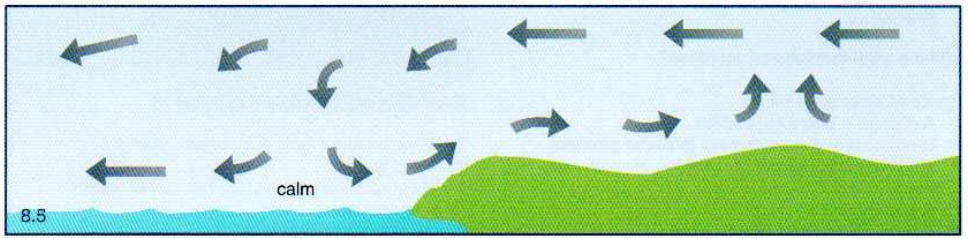



Above: The sea breeze Quadrants 1 and 2.

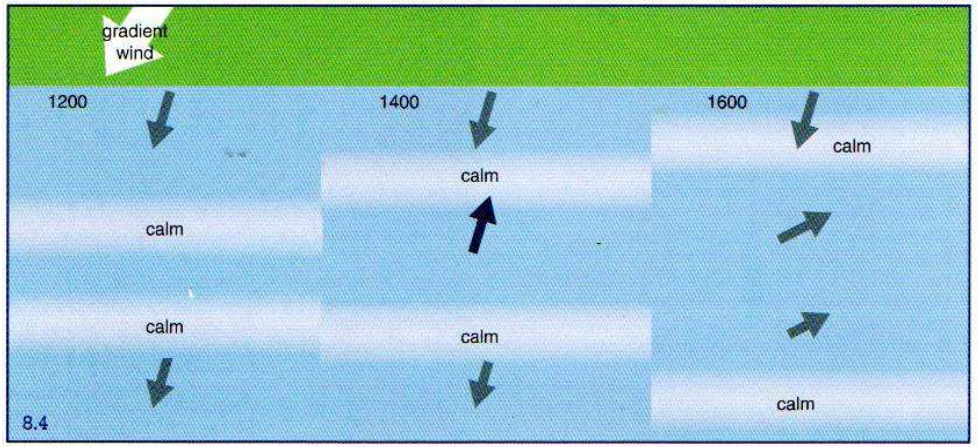
Below: the development of the sea breeze with a Quadrant 1 gradient wind. Quadrant 2 is shown overleaf.

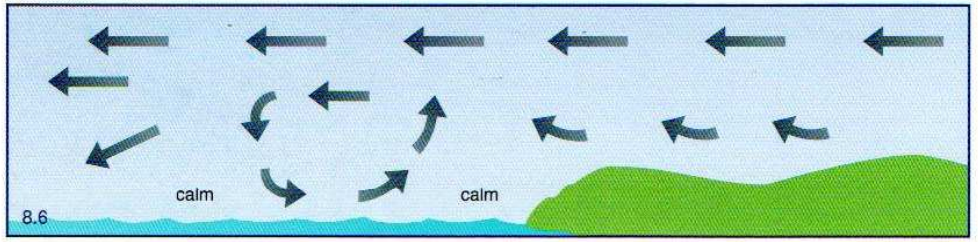



## The sea breeze with a Quadrant 2 gradient wind

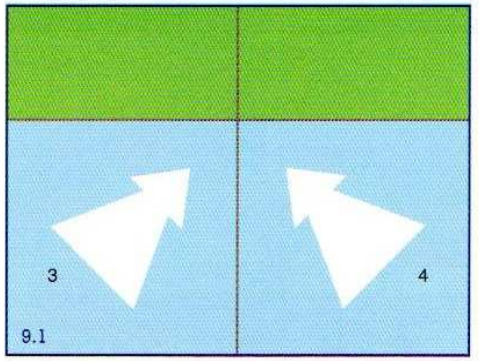



## Afternoon wind with gradient wind onshore

Heating of the land causes a fall of pressure which adds a component of wind of 4 or 5 knots parallel to the coast. This augments a Quadrant 3 wind especially if it is nearly parallel to the coast, but tends to kill a Quadrant 4 wind. The major differences between the enhancement of a Quadrant 3 wind and a true sea breeze are:

- The full benefit of the thermal enhancement is achieved only when the morning wind is within about 20 degrees from the line of the coast.
- The increase in speed is spread over a zone several kilometres wide.
- The change in direction depends on the strength and direction of the initial wind. It may only be a few degrees.




**Will the wind increase or decrease?**

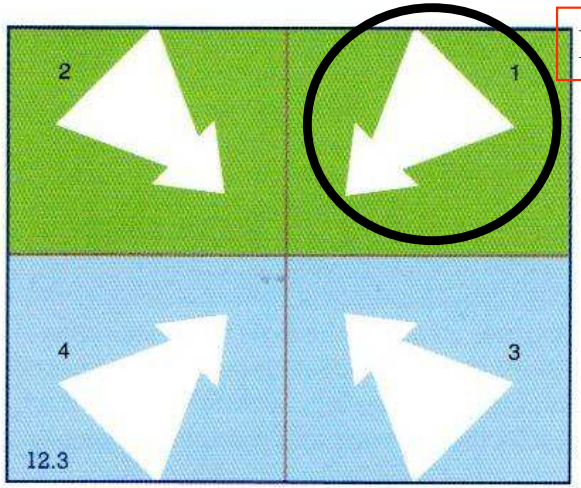
Check whether there will be:

- A change in pressure gradient.
- Development of a sea breeze (offshore gradient).
- Thermal enhancement or reduction of an onshore wind.
- A change in tide.
- A band of stronger or lighter wind.

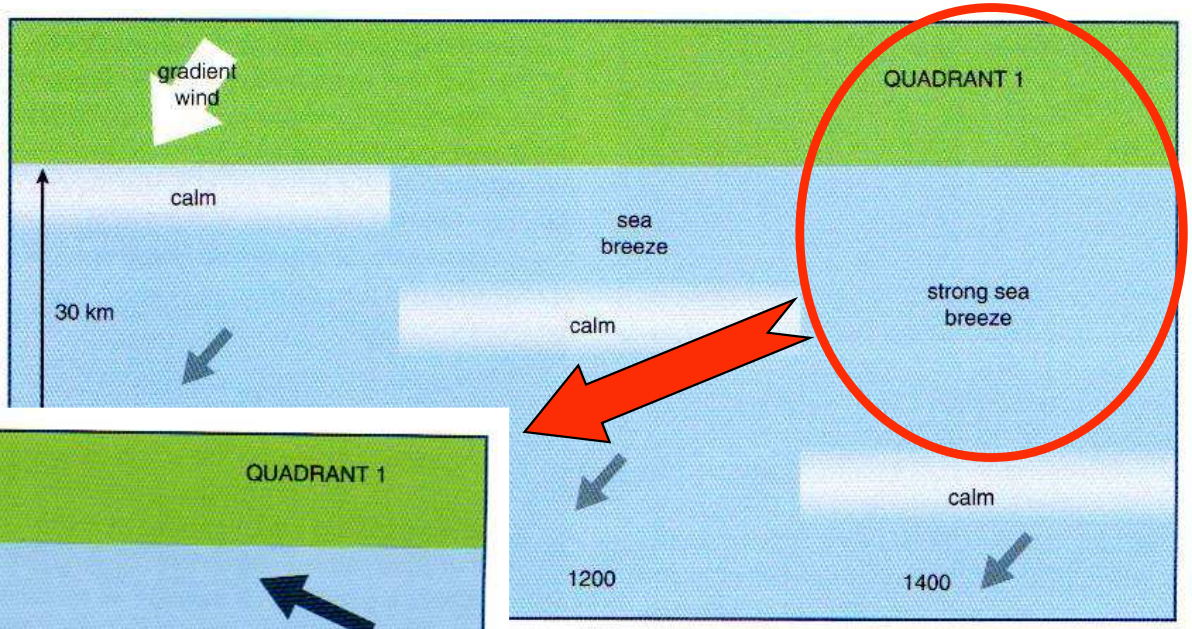
**If one side pays on a beat is it due to:**

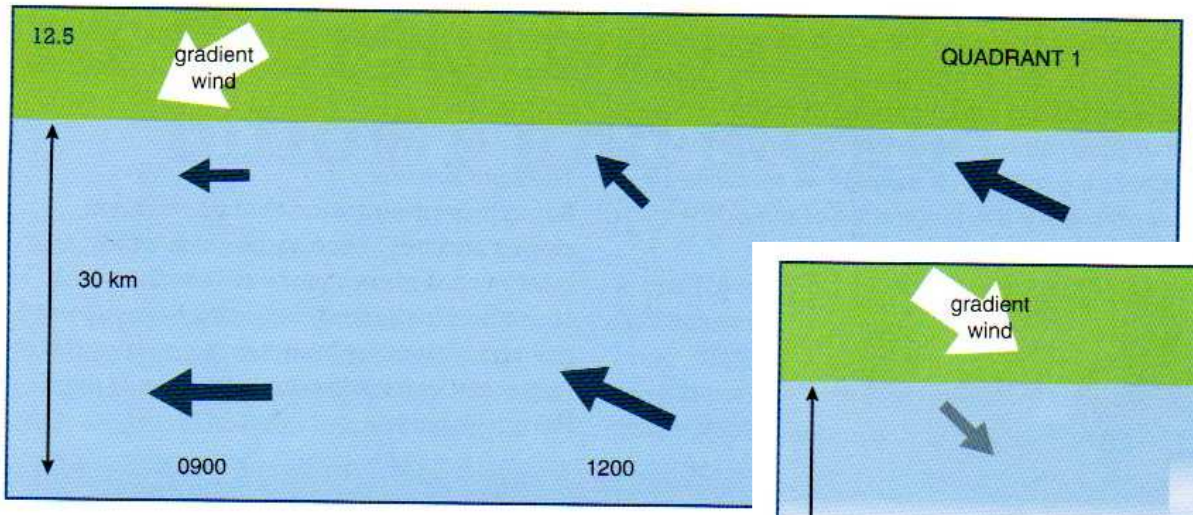
- A feature of the land or an island upwind.
- A sea breeze.
- Water temperature variations across or upwind of the course
- Current or tide variations.

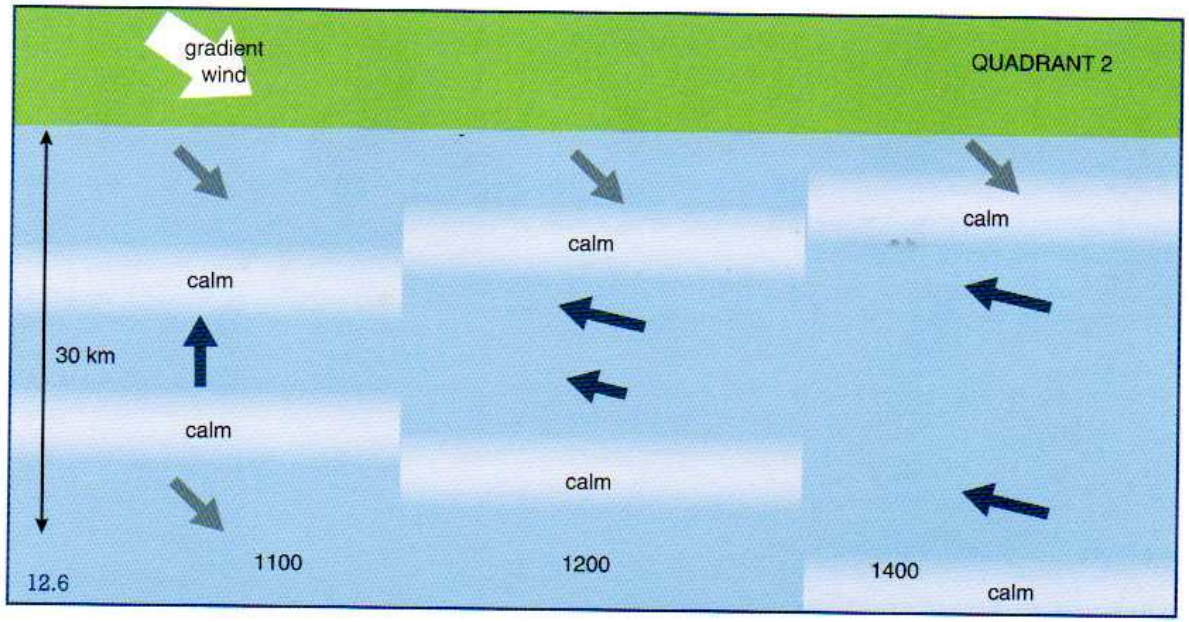
# *Southern Hemisphere: the sea breeze with gradient wind*




**Best gradient wind…**



# THE TWO SURFACE WINDS: THE WIND'S "PATTERN"…

- **Light air**
- **Breeze**

**Light air**: the **light airs** are those winds with an average speed of about 5kts or less. Their primary characteristic is that the flow speed is feeble near the surface and increases steadily with increasing height up to above 10m in 5kts but less in lighter airs. The weather forecasts is **not reliable** in the **light airs**…

**Breeze**: the **breezes** are those winds which have the properties of a turbulent boundary layer. The **breezes** are winds with average speeds of about 6kts or more. Their primary characteristic is that the change of speed with height is confineed almost entirely to the one to two meters closes the surface. The weather forecasts is **realiable** when the **wind speed is included between 7-8kts to 20-22kts**. **Up to 20-22kts** we have to expect an **underestimation in the forecast of the wind speed**…

- **Light air** patterns: *steady, unsteady, pulsing, oscillating, ribboning*
- **Breeze** patterns: *steady, wandering, pulsing, convergent/divergent, channeling, gusty*

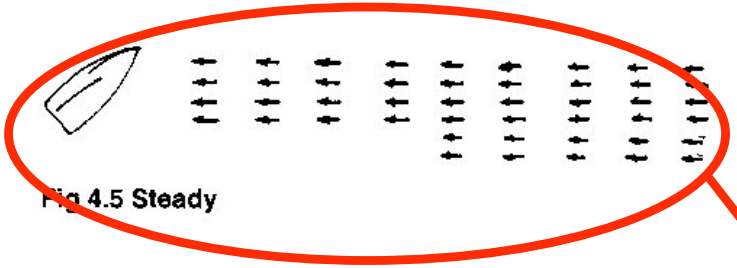


Fig 4.5 Steady

Fig 4.6 Unsteady

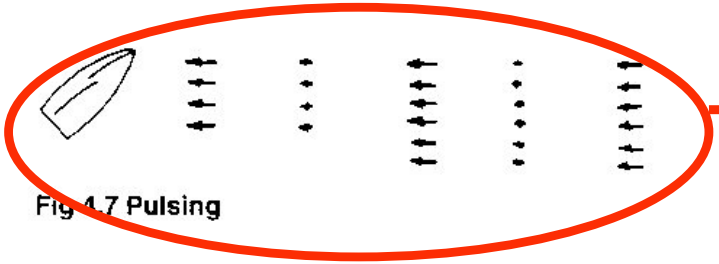


Fig 4.7 Pulsing

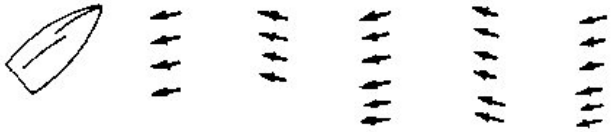


Fig 4.8 Oscillating

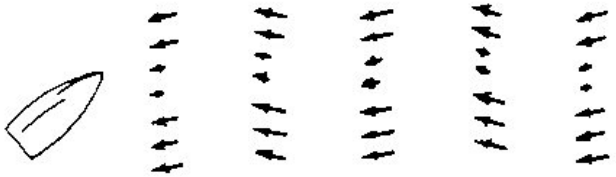


Fig 4.9 Ribboning

Arrow lengths indicate wind speed ← = 5 knots
Arrow directions suggests wind direction • = calm
Spacing of changes is typically 100 - 200 metres

**Figs 4.5 to 4.9**
**Helmsman's visualisation of approaching air**

**Light air patterns: *steady, unsteady, pulsing, oscillating, ribboning***

**Breeze** pattern: *steady*

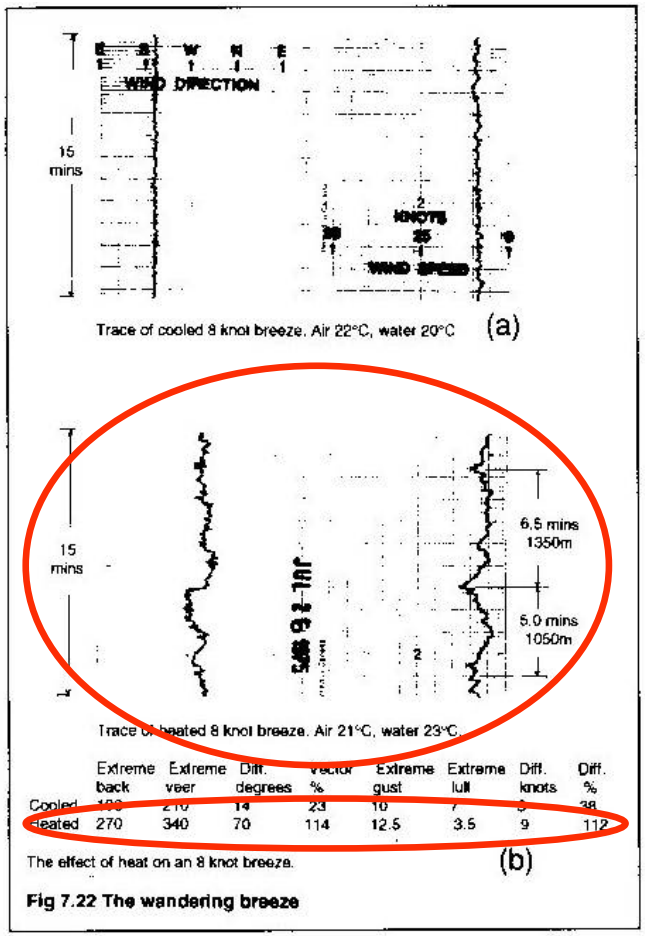
**Breeze** pattern: *pulsing*

**Breeze** pattern: *convergent/divergent* (see the following slides…)

# **Breeze** pattern: *wandering*

The **wandering breeze** will form on days when the air is heated strongly from the sea, the wind speed is beetween 6kts and 9kts and a Low pressure is dominant. The mechanism, circulation and surface winds which result are indentical in principle to that of *unsteady light air*…

Fig 4.6 Unsteady




Trace of cooled 8 knot breeze. Air 22°C, water 20°C

Trace of heated 8 knot breeze. Air 21°C, water 23°C.

| | Extreme back | Extreme veer | Diff. degrees | Vector % | Extreme gust | Extreme lull | Diff. knots | Diff. % |
|---|---|---|---|---|---|---|---|---|
| Cooled | 190 | 210 | 14 | 23 | 10 | 7 | 3 | 38 |
| Heated | 270 | 340 | 70 | 114 | 12.5 | 3.5 | 9 | 112 |

The effect of heat on an 8 knot breeze.

Fig 7.22 The wandering breeze

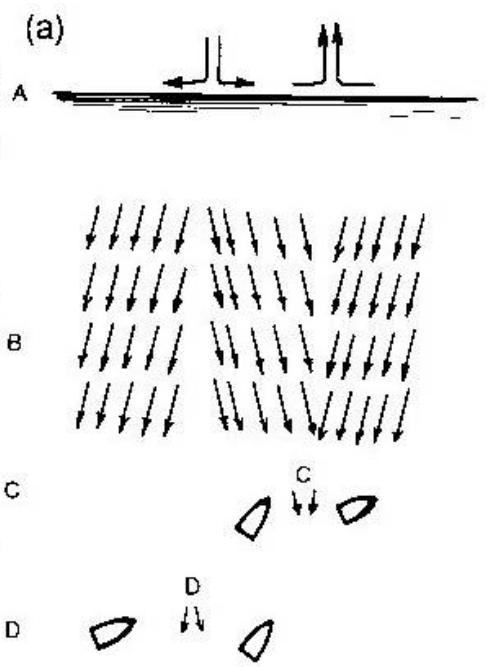
• Remember (in this pattern): ***"The gusts which don't come towards you"***. In fact they do, but much more slowly than one would expect. Normal technique is to sail to them and then to sail to remain in them. When there is a choice when you are sailing crosswind, sail to the upwind gust, otherwise your advantage will probably short-lived because the calm in the middle of the cell is likely to catch you later…

• On the assumption that you will experience two changes of wind speed and two changes of wind direction as you sail through each cell, when you sail upwind you can expect that there will be a significant change of something about every 200m or 2' on average… **It is as well to keep this in mind!!!**

• I have dealt to fairly thoroughly with the **wandering breeze**, because it is one of the commonest winds in which we race. It is also one of the most challenging to handle intelligently…

# **Breeze** pattern: *channelling*

The **channelling breeze** can form when the heating becomes more intense. It is similar to *ribboning light air*, but occurs in stronger breezes and at about ten times the scale.




Cross wind convergence/divergence due to heat. Mechanism: strong heating causes lines of rising and descending air.

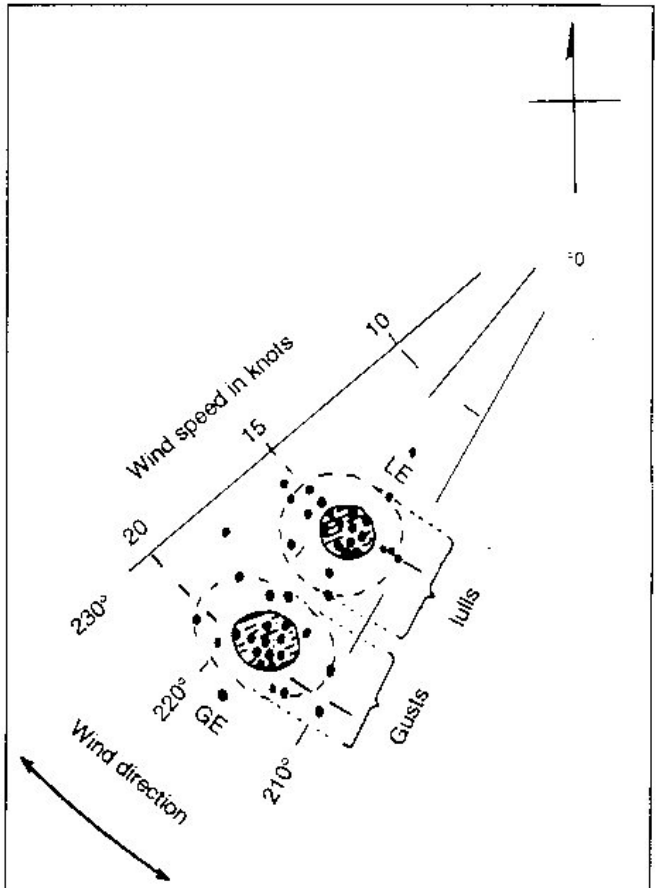
A = View looking upwind.
B = View of surface flows from above.
C = Windward boat gains in convergent situation.
D = Leeward boat gains in divergent situation.

**Two open-water convergent/divergent situations.**

ce.

- In appearance, the wind blows in upwind/downwind channels wich can last almost indefinitely. Between them are intervening channels of much lighter wind.
- The whole pattern usually moves crosswind slowly…
- The speed difference is so great as to be visually obvious…
- Typical dimension would be that the stronger-wind channels would be 200m to 300m across, while the intervening light-air channels would be perhaps twice that width.
- Note particularly that the stronger-wind channels are also zones of **diverging** air… Because of this, it is normal to find, when tacking upwind along the stronger-wind channel, that: ***"The boat won't point when approaching the core, but will point beautifully when through it"***…

# **Breeze** pattern: *gusty*




50% of gusts and lulls fall within the shaded circles.
90% " " " " " " " dashed "
GE= Extreme gust
LE= Extreme lull
*(Plots of average speeds and directions of 23 gusts and 24 lulls during one 30 minute period of breeze without heat.)*

**Fig 5.7 Plots of gusts and lulls**

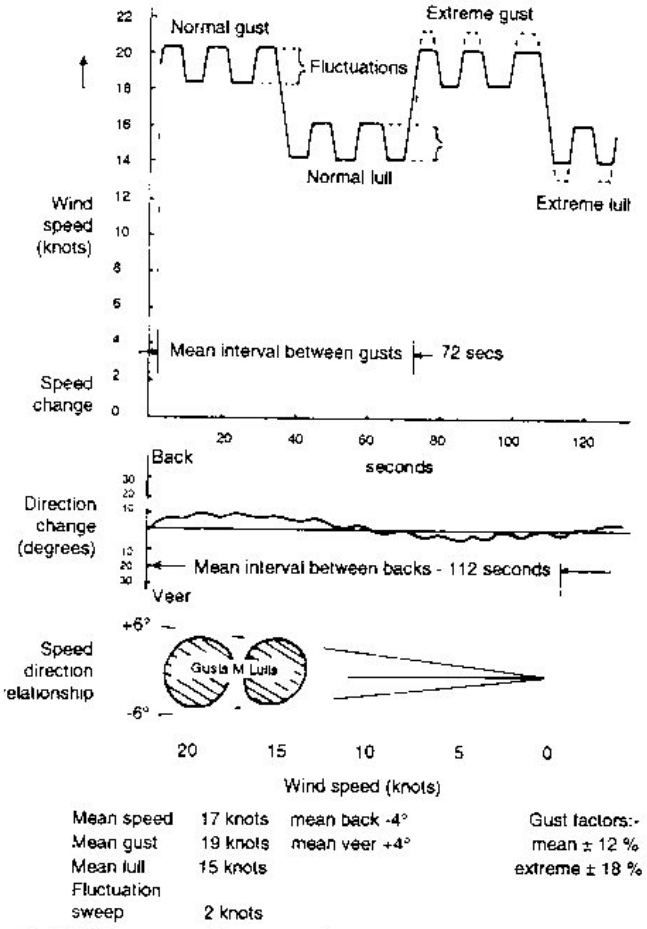



**Fig 5.8 Signature of breeze without heat**

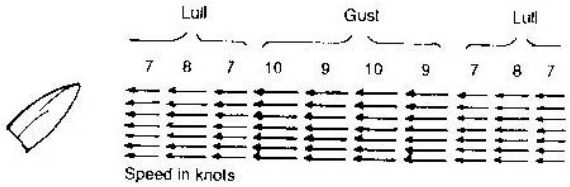
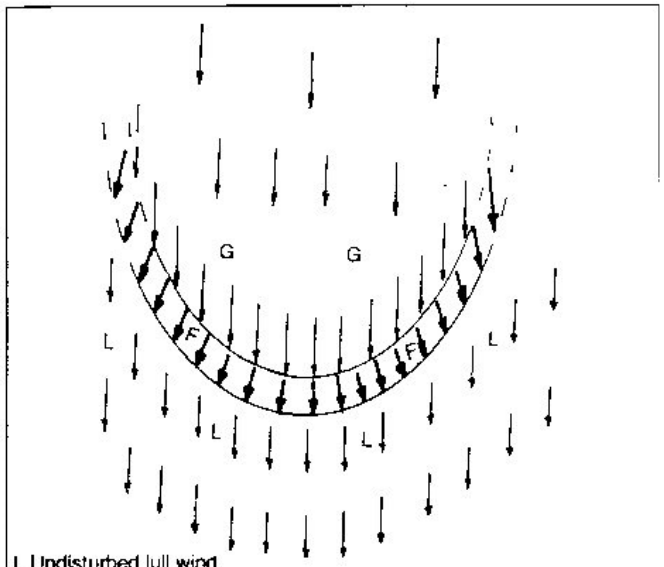



**Fig 5.9 Helmsman's visualisation of a cool breeze**

# **Breeze** pattern: *gusty* (*the Fan*)

As the mass of each gust advances, it undercuts and pushes aside the slower air ahead of it. The air just ahead of each advancing shoulder of the gust is moved forcefully at almost the speed of the gust in a direction angled outwards from the gust's direction. This is the **Fan**…




L Undisturbed lull wind.

G Gust wind which undercuts the lull wind.

F The 'fan', a fringe of air 25 to 50 feet wide which is displaced outwards by the advancing gust, in a direction away from the gust edge.

The fan passes over the water too quickly to form wind lanes.

**Fig 5.14 The fan**

- The **Fan** passes over each part of the water surface so quickly, it makes no visible wind lanes.
- A helmsman ahead of an approaching gust will be able to see the wind lanes around him in the lull and also the wind lanes within the gust. Between the two there will be the **Fan**…
- This will appear to the helmsman as a wind of a different direction which has a dimension of two or three lenghts of a small boat!!!
- **ALERT**: crews who are aware of the fan can use this to free sheets, flick their boat onto a plane and steer along the fan at greatly increased of the VMG.
- **ALERT**: it is downwind that "riding the fan" really comes into its own. Crews of high-performance, planing, downwind tacking dinghies, or fast catamarans, can steer to intercept the fan and then bear away to accelerate in it and steer to stay in it…

# Test in pillole (2’ per rispondere)

- Quali sono le migliori condizioni per lo sviluppo della termica di mare?

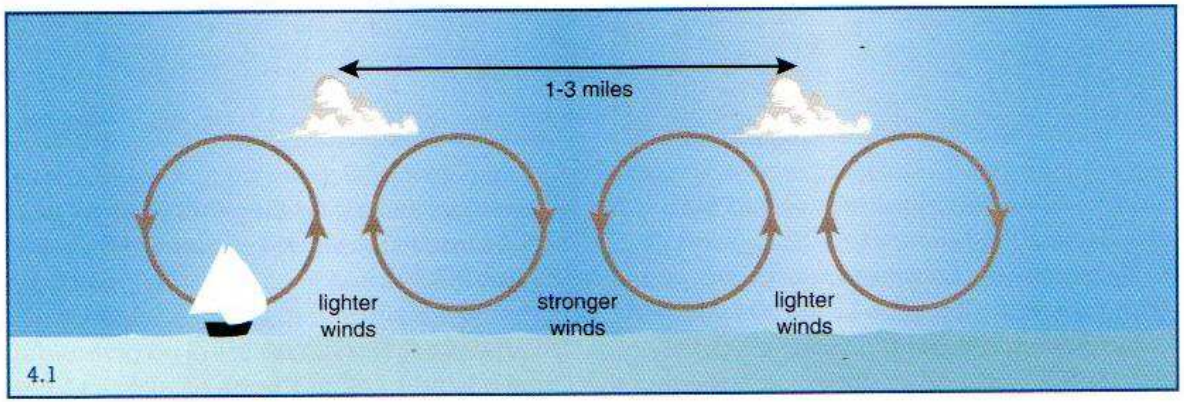
1. Vento di gradiente a 1000m da terra (TWS=6÷9kts) e Ta-Ts=2÷4°C
2. Vento di gradiente a 1000m da terra (TWS=11÷13kts) e Ta-Ts=6÷8°C
3. Vento di gradiente a 1000m dal mare (TWS=6÷9kts) e Ta-Ts=1÷2°C
4. Vento di gradiente a 1000m da terra (TWS=8÷10kts) e Ta-Ts=0÷-2°C

- Quali sono le condizioni per trovarsi nel «pattern» di vento chiamato «wandering»?

1. Ta>Ts; TWS=6÷9kts; low pressure
2. Ta>Ts; TWS=5÷7kts; high pressure
3. Ta<Ts; TWS=11÷13kts; high pressure
4. Ta<Ts; TWS=6÷9kts; low pressure

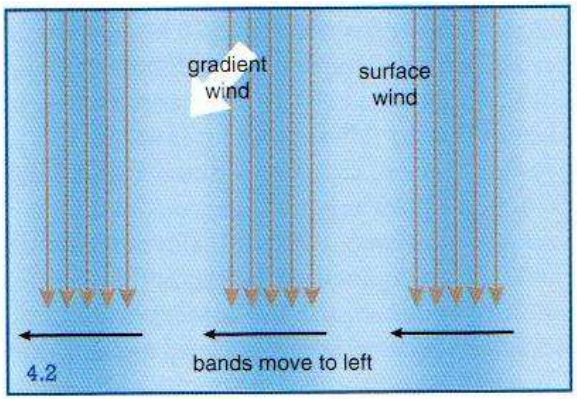
*Winds near clouds*

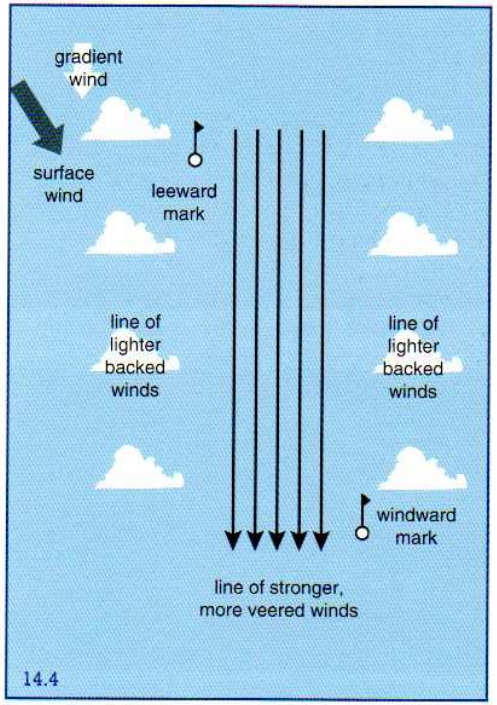
# ROLL CLOUDS (1)



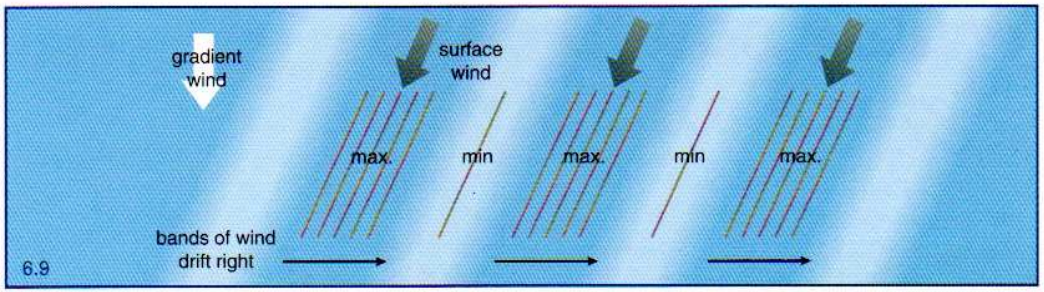
# ROLL CLOUDS (2)

## *Northern Hemisphere*

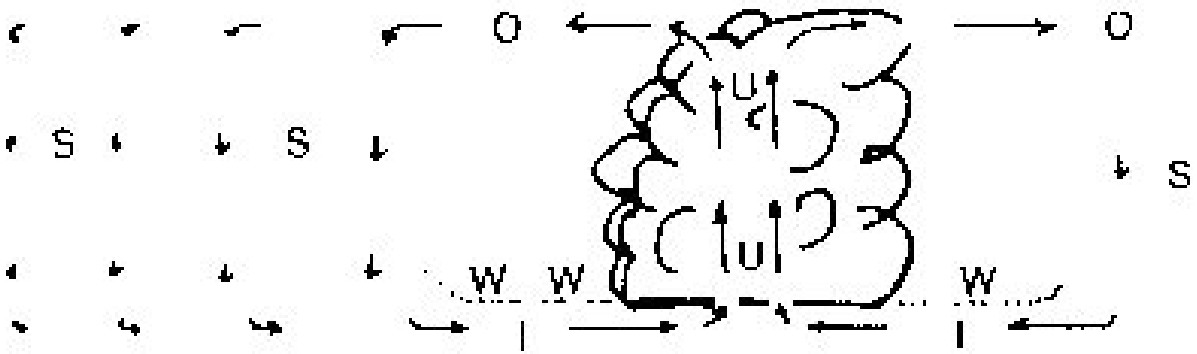



## *Southern Hemisphere*



# CUMULUS CLOUDS – NON RAINING (1)

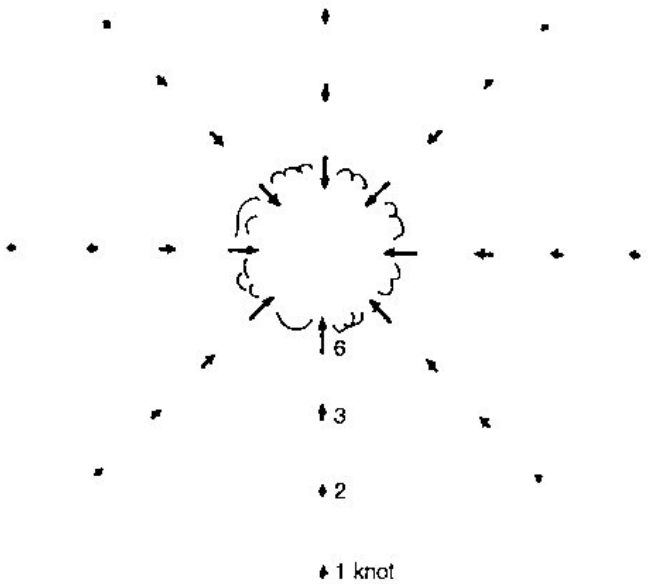



U = Updraught as warmed air rises
O = Outflow at cloud top level
S = Gentle subsidence over wide area
| = Inflow at and below cloud base level
W= Wisps of cloud sometimes form when inflow is strong enough to create turbulence.

**Fig 8.4 Circulation around and below non-raining cloud**

# CUMULUS CLOUDS – NON RAINING (2)

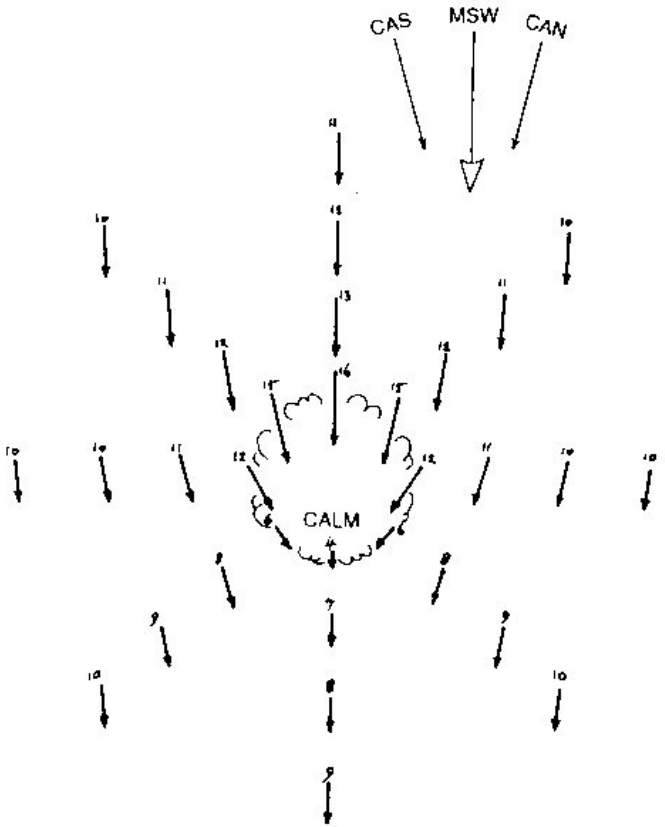
## *Steady clouds…*




Speeds suggested are typical, and indicate change of speed with increasing distance from cloud edge.

**Fig 8.5 View from above of surface wind pattern under low-based, non-raining cumulus cloud.**

## *Moving clouds…*

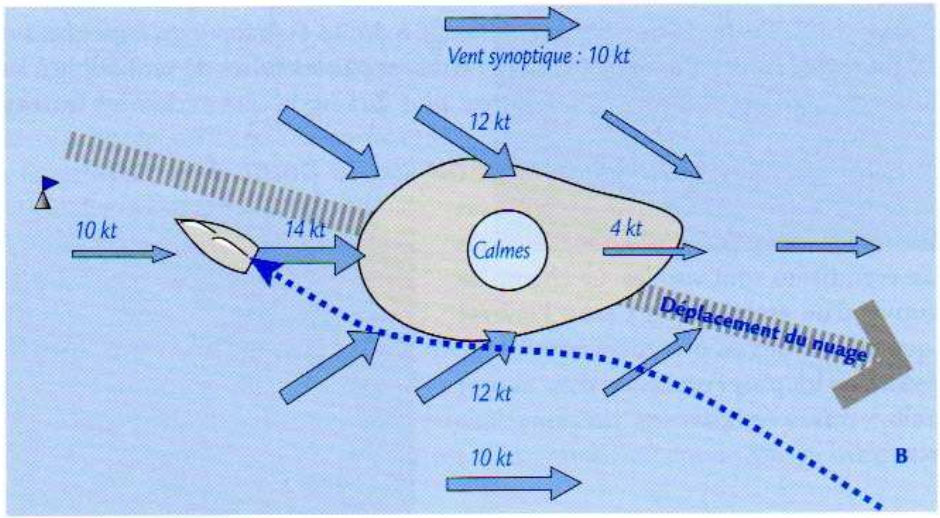


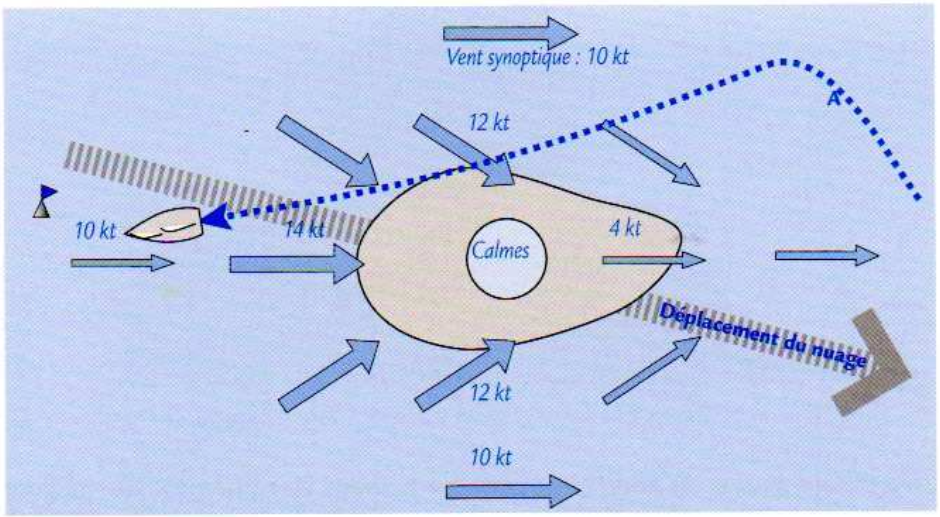

Surface wind pattern in 10 knot breeze near and under low-based, non-raining Cumulus cloud.

Note:
You sail in the surface wind -
but the cloud is steered by the gradient wind aloft - so
MSW = Mean direction of surface wind
CAS = Cloud approach, southern hemisphere
CAN = " " northern "

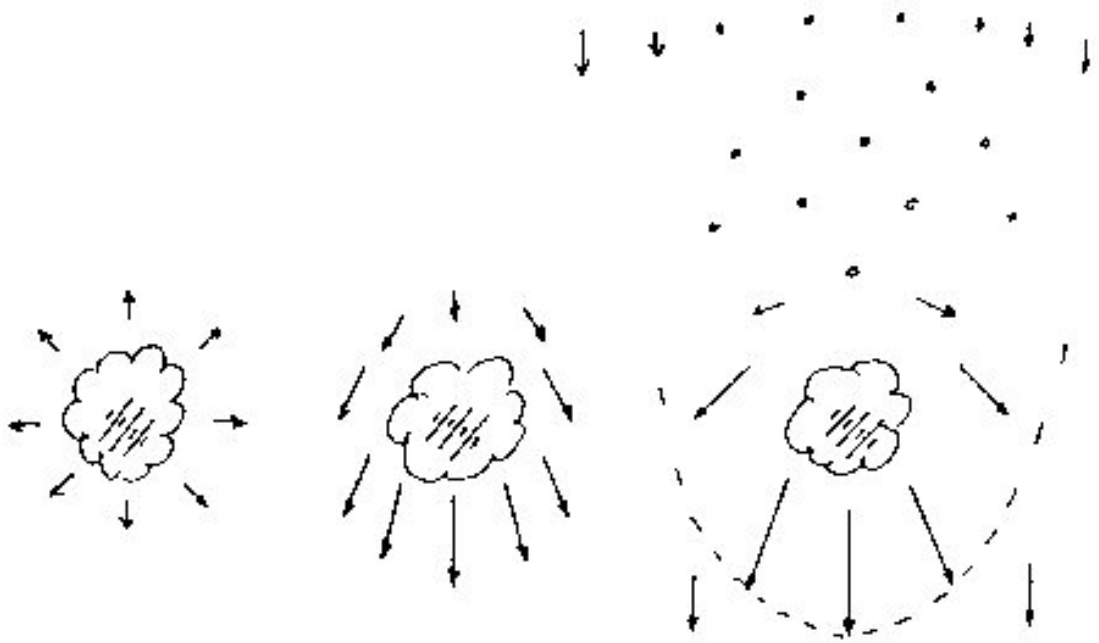
**Fig 8.6 Surface wind pattern near non-raining cloud**

# CUMULUS CLOUDS – NON RAINING (3)



# CUMULUS CLOUDS – RAINING (1)



Small cloud
Raining
Calm
Outflow 5 knots

(a)

Small cloud
Raining
Wind 10 knots
Outflow 5 knots

Simple pattern
No calm area.

(b)

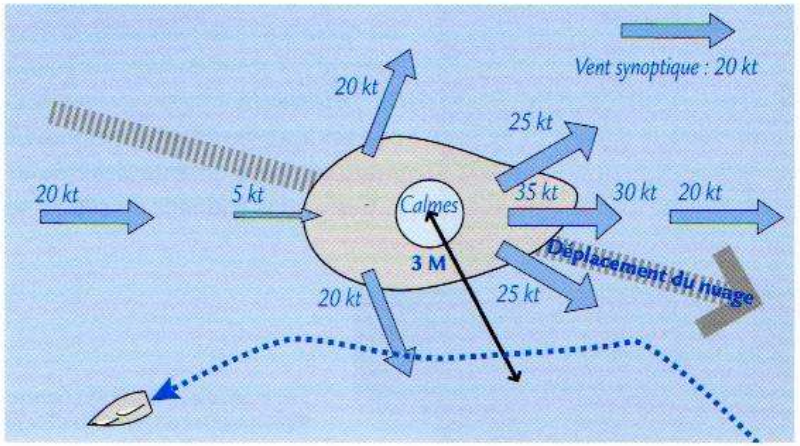
High based cloud
Raining
Wind 10 knots
Outflow 10 knots, and cold

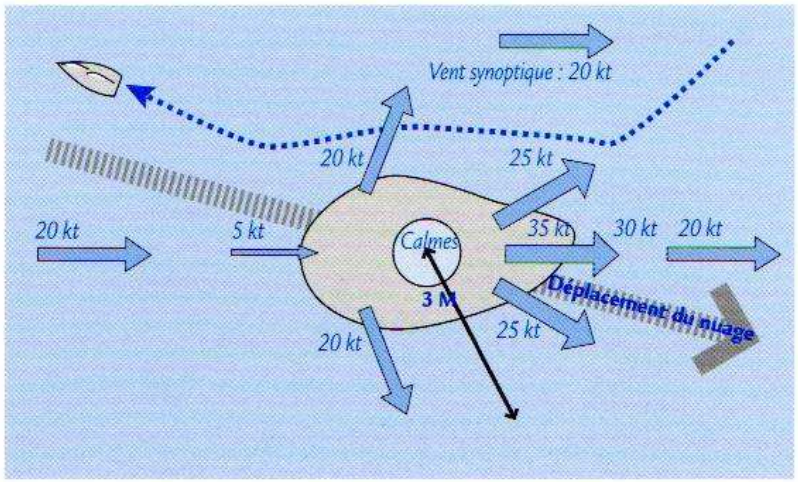
Complex pattern
Extensive calm area

(c)

**Fig 8.8 Surface wind patterns near raining clouds**

# CUMULUS CLOUDS – RAINING (2)



# Test in pillole (2’ per rispondere)

- Nell’emisfero Nord, considerando delle nuvole tipo Cu, Cb oppure Ac che si spostano per il vento di gradiente, dovrò osservare le nuvole che:

1. Provengono dalla mia area frontale
2. Provengono da destra
3. Provengono da sinistra
4. Nessuno dei tre precedenti

- In un «Cu towering» oppure in un Cb in formazione (che non sta ancora dando precipitazione) il «pattern» di vento sarà:

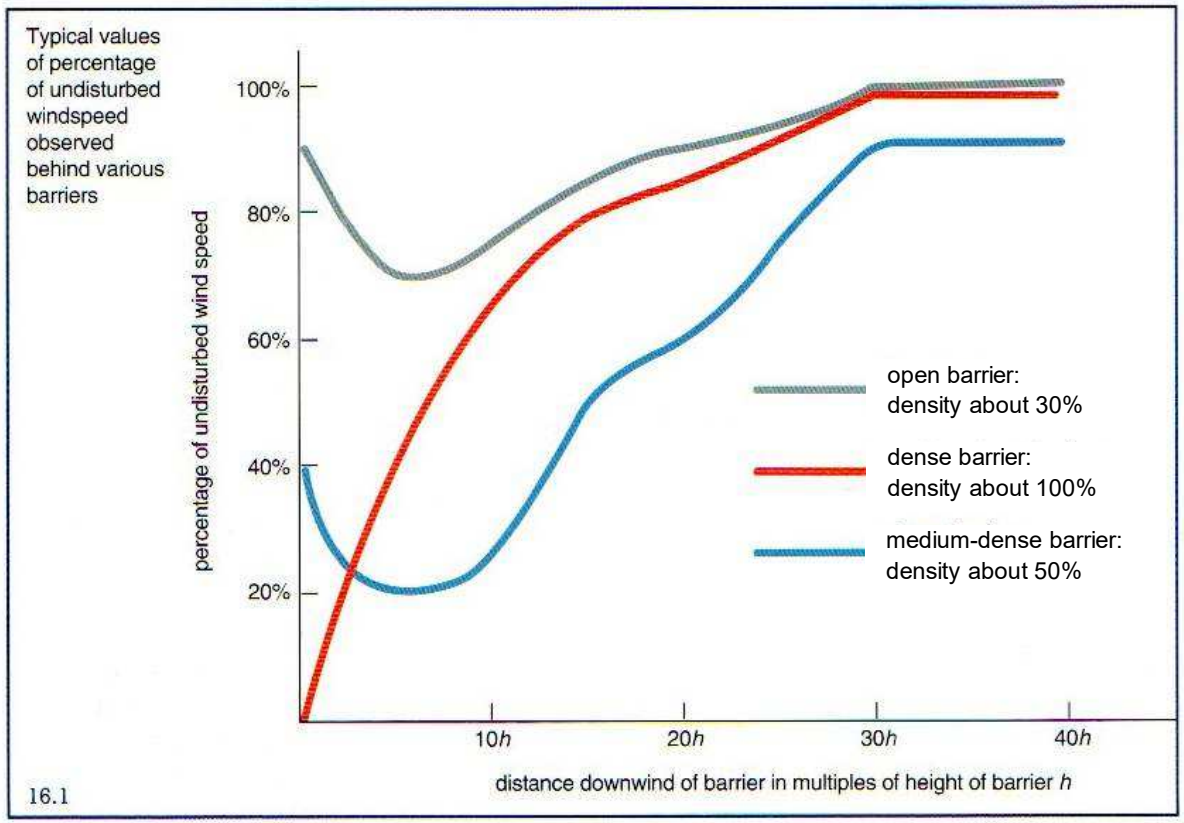
1. Vento uscente dalla parte frontale della nuvola e molto intenso, entrante nei lati e nella parte posteriore della nuvola e meno forte in queste due ultime aree
2. Vento sempre uscente da tutte le parti della nuvola
3. Vento uscente dalla parte frontale della nuvola e meno intenso, entrante nei lati e nella parte posteriore della nuvola e più forte in queste due ultime aree
4. Nessuno dei tre precedenti

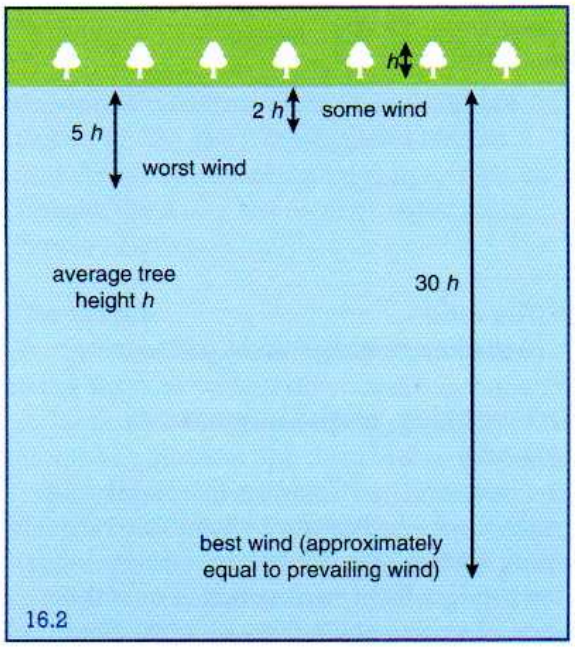
*Obstacles in the wind*

# OBSTACLES IN THE WIND (1)

There are many types and densities of barrier: buildings, trees, forests, walls, fences and boats. Some are short, some tall, but their **influence on the wind** is a **function** primarily of the **height** and **average density** barrier.

**Density** might be loosely defined as *the amount of daylight that a barrier lets through*. Thus a brick wall has a density of 100%, a well spaced row of trees has a density about 30%...



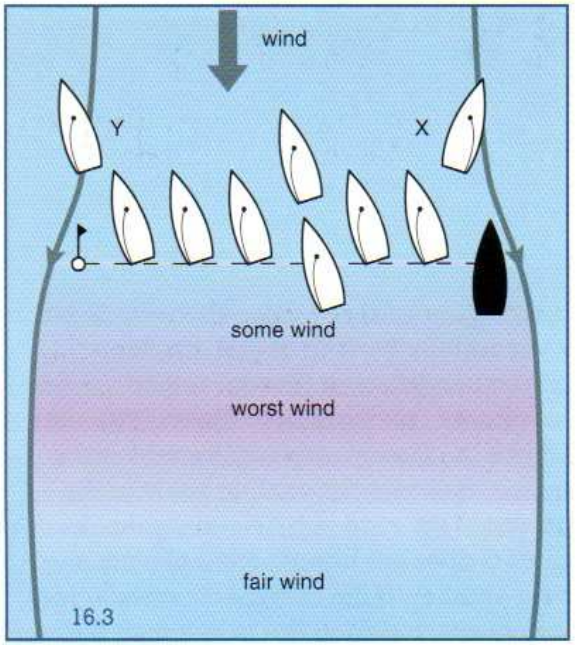

Open barrier

# OBSTACLES IN THE WIND (2)

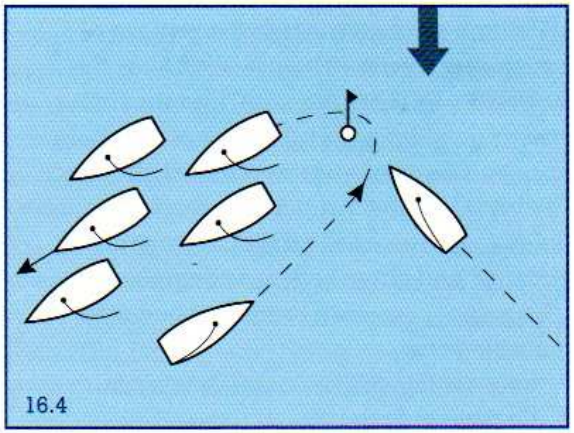
For all but the most solid barrier there is a zone of lowes wind speed about 5 times the height of the barrier downwind from it…

A medium to dense barrier is a much more effective obstacle to the wind than a dense one such as a brick wall or a thick hedge…

For most barriers other than the medium-dense variety, the wind recovers to 75% of its original average speed at a distance roughly 10 times the height of the barrier downwind…

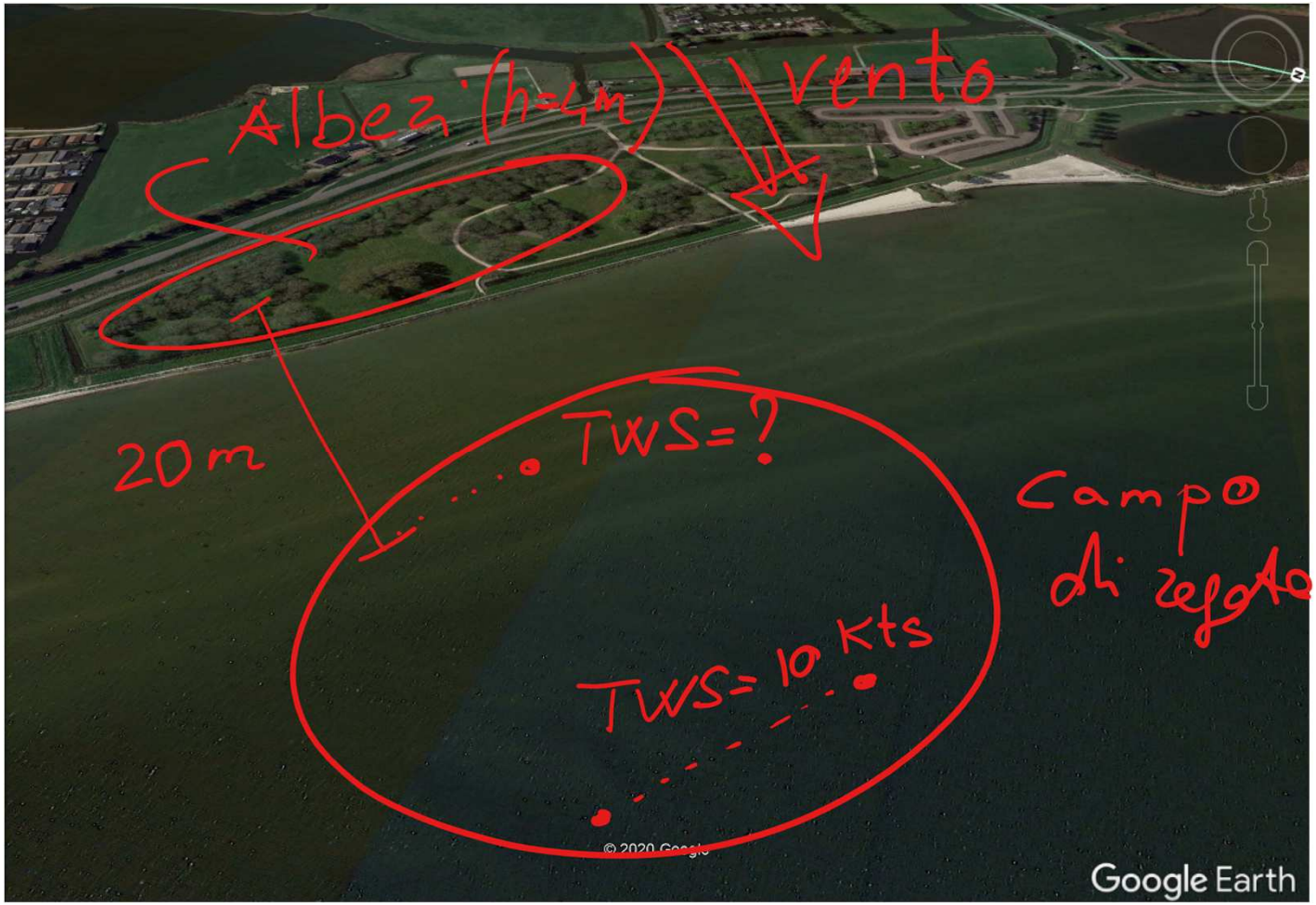



A massed start of 100 or so boat could be described as a medium-dense barrier and it is likely to disturb the wind for a distance of 30 to 40 times its height downwind. The fleet a the start not only interferes with the wind but causes it to bend around the edges




You have to point up the dangers of approaching the windward mark on port tack if you are fairly well down to the fleet. The boats already on the reach will form a medium-dense barrier to the wind in which it will be almost impossible to sail…

# Test in pillole (2’ per rispondere)

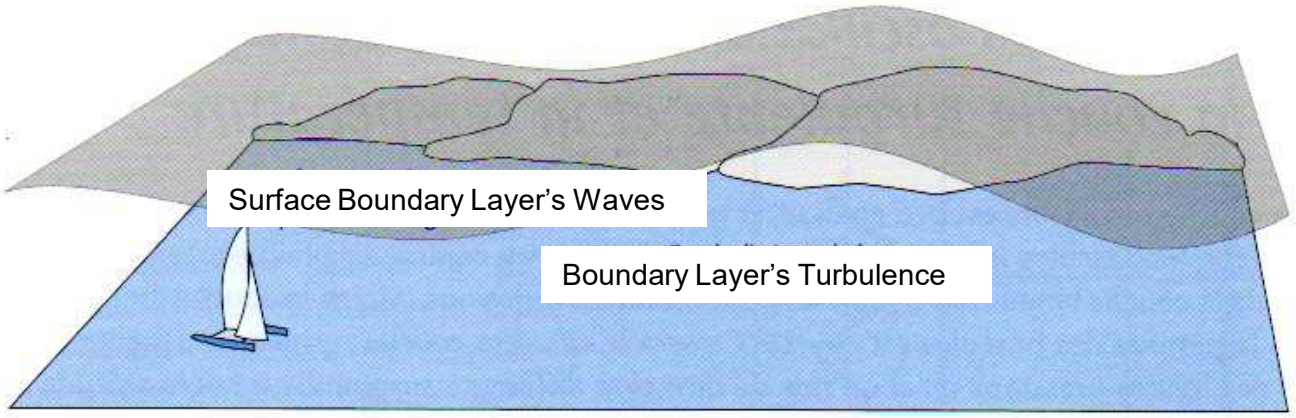



- Quale intensità del vento supponiamo di trovare nella zona della boa di bolina?

1. 20 kts
2. 7kts
3. 10kts
4. 9kts

*The oscillations*

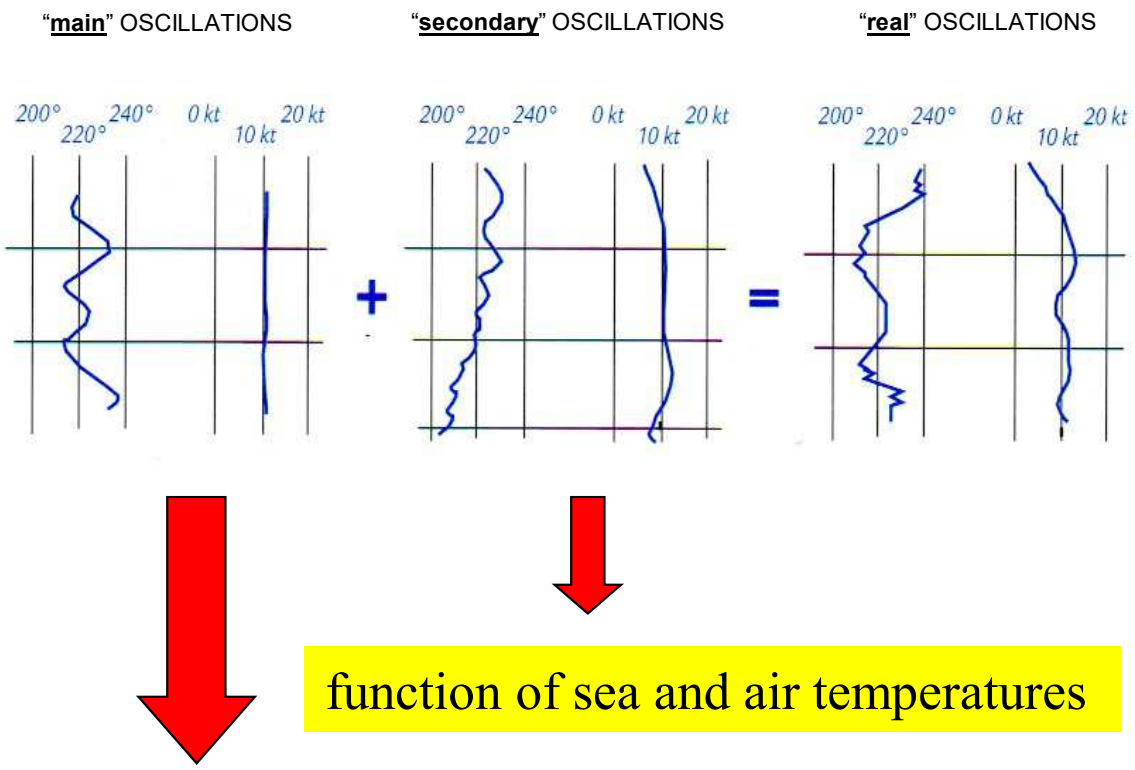
# OSCILLATION: WIND FACTS… (1)




Surface Boundary Layer: height from 100m to 3000m (function of atmospheric pressure)

Boundary Layer's Turbulence: function of the sea temperature (Ts) and the air temperature (Ta)

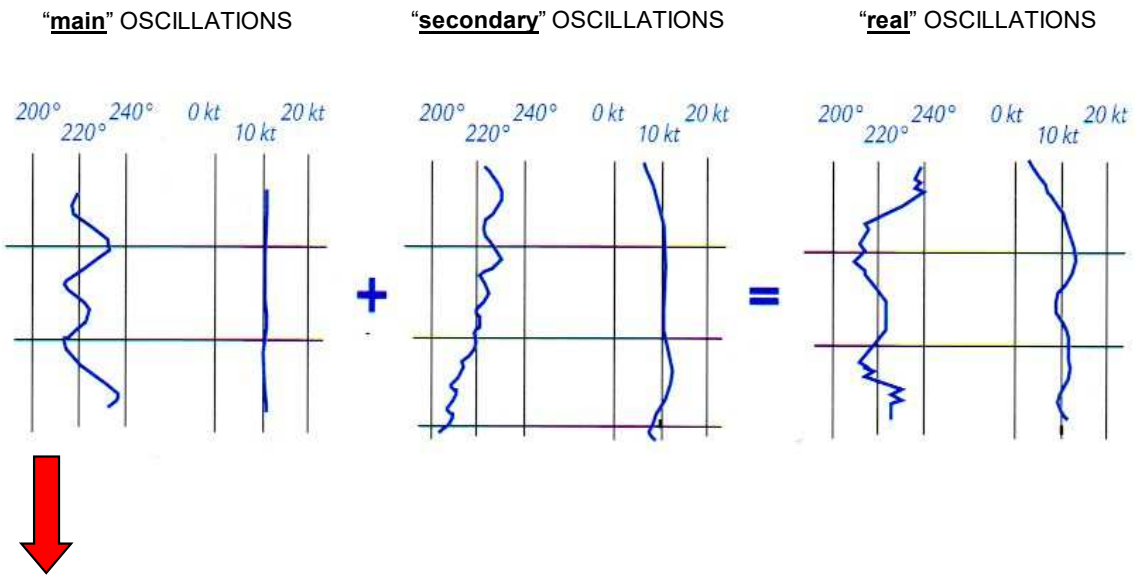
# OSCILLATION: WIND FACTS… (2)




function of sea and air temperatures

function of atmospheric pressure

# OSCILLATION: WIND FACTS… (3)

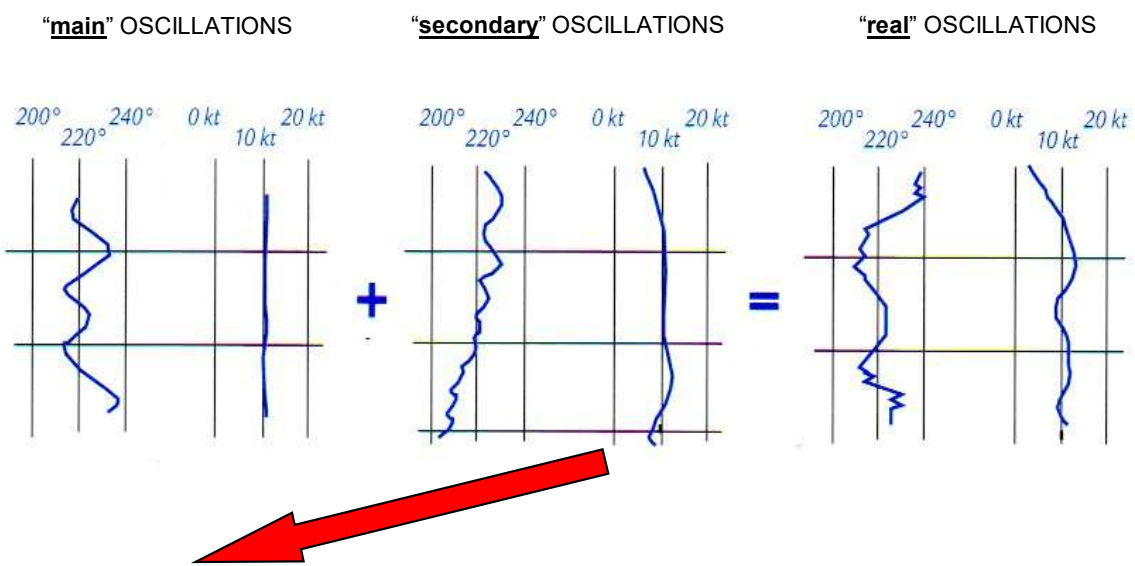



Surface Boundary Layer:

• **thin**: the "**main**" oscillations are regulars in the period and little in the width (little angle). We have this situation in the *high pressure "patterns"*…

• **thick**: the "**main**" oscillations are irregulars in the period and big in the width (big angle). We have this situation in the *low pressure "patterns"*…

# OSCILLATION: WIND FACTS… (4)



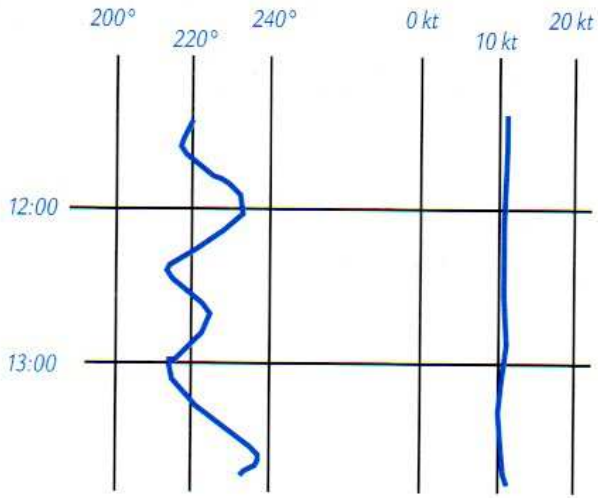

Boundary Layer's Turbulence :

• **Ta>Ts (stable air)**: the "**secondary**" oscillations are *regulars* and little (in the direction and in the speed)…

• **Ta<Ts (unstable air)**: the "**secondary**" oscillations are *irregulars* in the period and big (in the direction and in the speed)…

# OSCILLATION: PATTERN… (1)

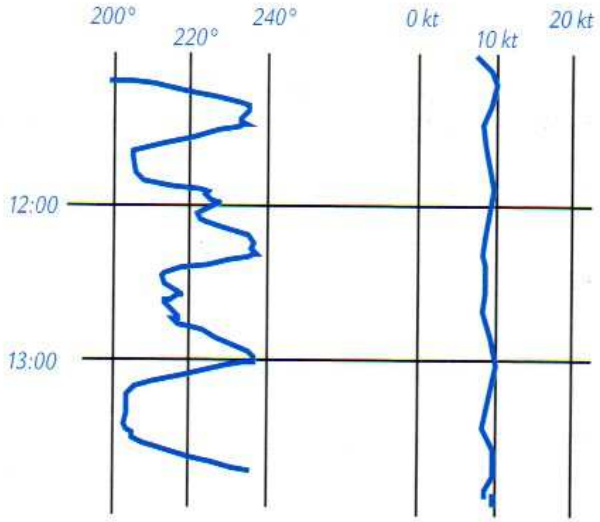
## High pressure and stable air




| | |
|---|---|
| **Weather Pattern** | Cooled and controlled air |
| **Atmospheric pressure** | High pressure or increasing air pressure |
| **Air temperature (Ta) & Sea Temperature (Ts)** | Ta>Ts (Ta-Ts>1°C) |
| **Oscillations & Shift** | Medium-long oscillations, more or less around 10'-20' with an angle included between 005°-010° (max. 010°-020°) |
| **Strategy** | "Classical oscillating wind". If you reach the *mark* in a time more longer that the semi-period of the oscillations, you tacking when the wind come back to the mean wind direction. Otherwise you play with the oscillations as a persistent shift… |

# OSCILLATION: PATTERN… (2)

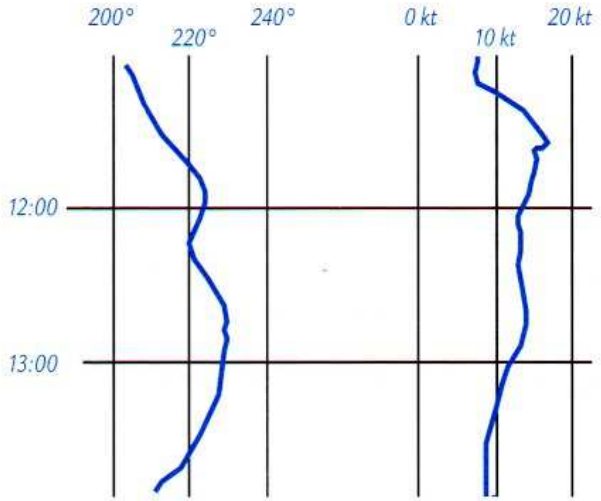
## High pressure and unstable air




| | |
|---|---|
| **Weather Pattern** | Warmed and controlled air |
| **Atmospheric pressure** | High pressure or increasing air pressure |
| **Air temperature (Ta) & Sea Temperature (Ts)** | Ta<Ts (Ts-Ta>2°C) |
| **Oscillations & Shift** | "**Secondary**" OSCILLATIONS included between 2'-3' for 005°-010° superimposed a the "**main**" OSCILLATIONS included between 10'-20' for 020°-040° |
| **Strategy** | We have the regular "**main**" OSCILLATIONS and some random and superimposed "**secondary**" OSCILLATIONS. We have to use the "**main**" OSCILLATIONS as the "*persistent*" shifts and we use the "**secondary**" OSCILLATIONS for tactical reason and strategical adjustment in the axis of the course |

# OSCILLATION: PATTERN… (3)

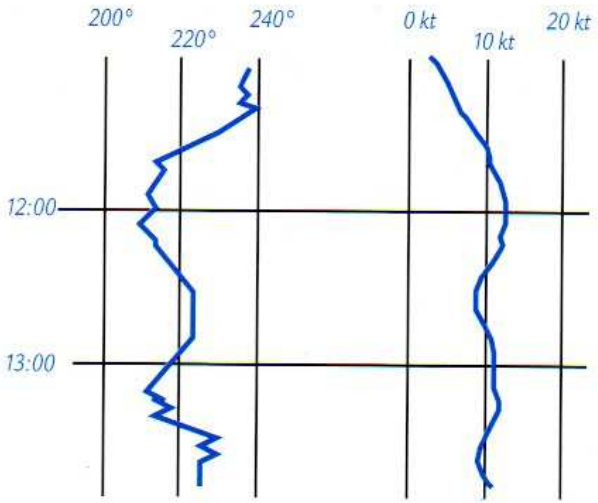
## Low pressure and stable air




| | |
|---|---|
| **Weather Pattern** | Cooled and uncontrolled air |
| **Atmospheric pressure** | Low pressure or decreasing air pressure |
| **Air temperature (Ta) & Sea Temperature (Ts)** | Ta>Ts (Ta-Ts>1°C) |
| **Oscillations & Shift** | Long oscillations, more or less 15'-30' as the persistent shifts, with big angle included between 020°-040°. It will be very difficult to found an average direction due to the long period of the oscillations |
| **Strategy** | Danger!!! It is very difficult to know the period of the oscillations, so it is very difficult to be well positioned in function of the oscillations… We don't have any "**secondary**" OSCILLATIONS that they can help us to *return* if we stay in the wrong side. You have to stay **careful**!!! |

# OSCILLATION: PATTERN… (4)

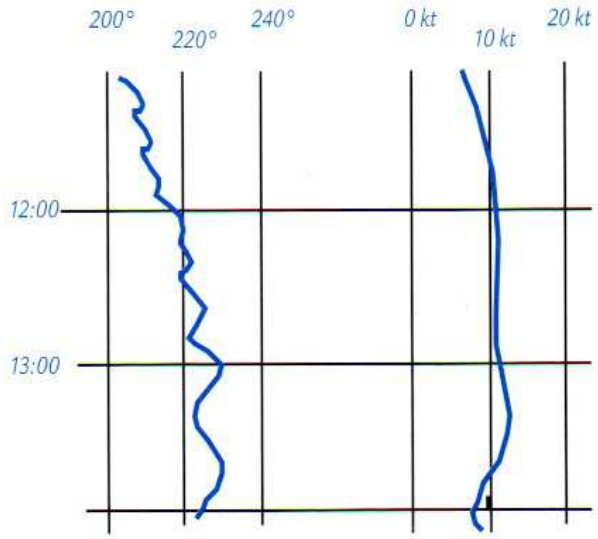
## Low pressure and unstable air

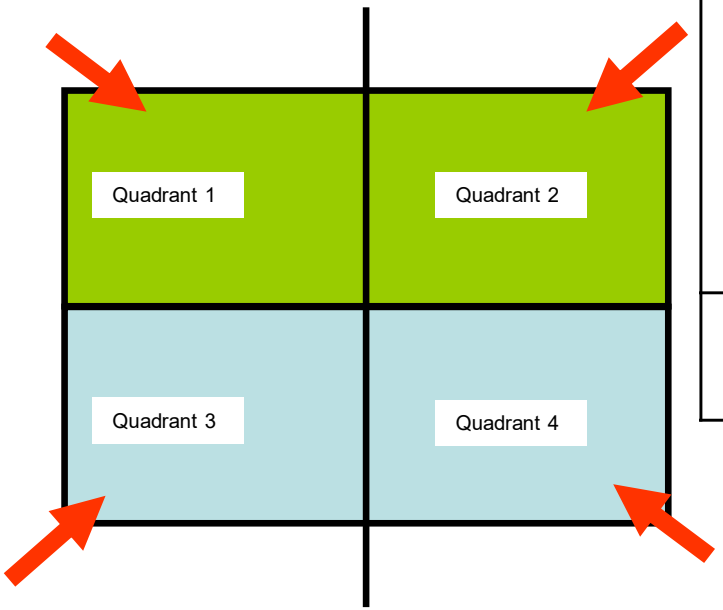



| | |
|---|---|
| **Weather Pattern** | Warmed and uncontrolled air |
| **Atmospheric pressure** | Low pressure or decreasing air pressure |
| **Air temperature (Ta) & Sea Temperature (Ts)** | Ta<Ts (Ts-Ta>2°C) |
| **Oscillations & Shift** | Random "**main**" OSCILLATIONS included between 15'-30' for 020°-040° superimposed a the "**secondary**" OSCILLATIONS included between 2'-3' for 005°-010° |
| **Strategy** | You have to be very opportunist and sailing in the oscillations. The "**secondary**" OSCILLATIONS can help you to adjust in the axis of the course and you will can use these oscillations also for *tactical placement*…You have to tack when the wind refuses you… |

# OSCILLATION: PATTERN… (5)

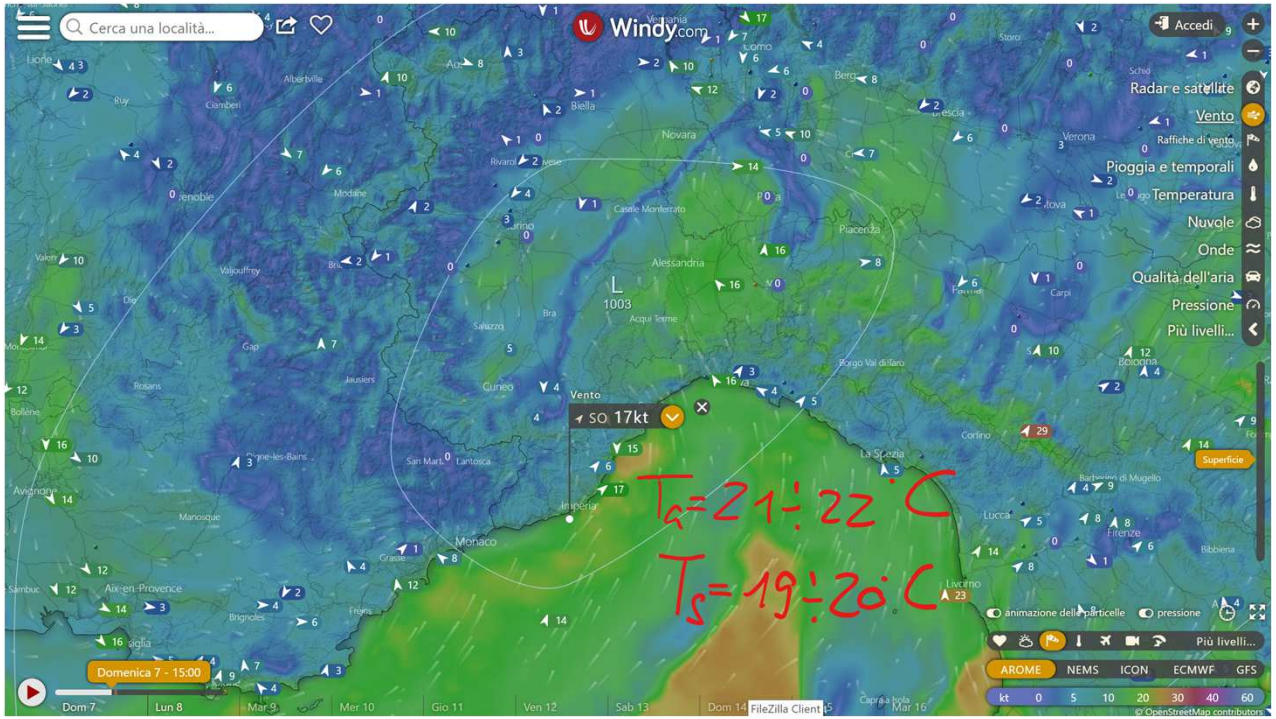
## Sea Breeze…




| | |
|---|---|
| **Weather Pattern** | Cooled and controlled air |
| **Atmospheric pressure** | High pressure |
| **Air temperature (Ta) & Sea Temperature (Ts)** | Ta>Ts (Ta-Ts>2°C) |
| **Oscillations & Shift** | Regular oscillations (period around 5'-10' with angle between 002°-005°) and right shift in the North Hemisphere (left shift in the South Hemisphere). After 14.00-15.00LT the oscillations will be bigger in period (10'-15') and in angle (005°-008°, max. 010°)…<br>You will have, in the North Hemisphere, for the **gust**:<br>• gradient wind from **quadrant 1**: in the most important gusts, you will have a right hand shift<br>• gradient wind from **quadrant 2**: in the gusts, you will have the random oscillations<br>• Gradient wind from **quadrant 3**: in the most important gusts, you will have a prevailing left hand shift |
| **Strategy** | Play with the shift of the sea breeze and with the oscillations in the gust (only if the sea breeze is fully developed…) |

# Test in pillole (2’ per rispondere)




- Regata di Optimist davanti a Imperia con vento da SW di 15-17kts. Come sfrutto le oscillazioni per il primo bordo di bolina (circa 15-30’)?

1. Le oscillazioni sono prevedibili e regolari di circa 15’ di periodo e 10° di angolo. Sfrutto le oscillazioni e navigo strategicamente
2. Le oscillazioni sono imprevedibili e solo primarie. Sto molto attento nella strategia e cerco di navigare quanto più tatticamente possibile
3. Le oscillazioni sono imprevedibili ma sono presenti sia le primarie che le secondarie. Sto molto attento nella strategia, ma cerco di sfruttare le oscillazioni secondarie per correggere il mio posizionamento
4. Nessuna delle tre

# ELEMENTI DI METEOROLOGIA PER LO SPORT DELLA V[illegible]A

# CORSO ATLETI[illegible]O LIVELLO
# CORSO ALLEN[illegible]RI ALTO LIVELLO

GRAZIE PER L'ATTENZIONE!!!

[illegible]uro Pezzoli, PhD FRGS AFRIN PMP
*[illegible]rofessore Aggregato Weather Risk Management*
*Laurea Ma[illegible]conomia dell'Ambiente, della Cultura e del Territorio – Università di Torino*

XV Zona - Online, 14 Gennaio 2022