METEOROLOGY IN REGATTA

Local wind, thermal breezes, pressure gradients, and strategic reading of the racecourse.

A practical guide to turning meteorology into race decisions.

*Based on the talk by Freddie Parton, meteorologist specialising in applied regatta meteorology. More at **freddieparton.com***

BORJA MAS

&

FREDDIE PARTON

Sailing Coach · ForSailors.es

Follow us on Instagram: @for_sailors · @borjamasv

Why meteorology decides regattas

The question that makes the difference is not just **"where is the wind coming from?"** but four chained questions: what regime do I have right now?, why is it happening?, how will it evolve during the race?, and what do I need to do before the rest of the fleet? A sailor who answers these four questions before the start makes decisions — they don't just react.

Meteorology doesn't compete with tactics: it comes first. Strategy is about managing the wind, the race course, the current, and how the day evolves. Tactics is about managing rivals, crossings, and manoeuvres. Without strategy, tactics becomes crisis management. Prior meteorological analysis generates a working hypothesis that must be tested and updated on the water — not memorised like a dogma.

Aarhus is a particularly demanding venue in this respect. The bay is surrounded by land, the sea breeze cycles are fast, and transitions can be sudden. The sailor who arrives with a clear picture of the expected regime and a validation plan has a structural advantage over those who simply check the wind bar on their phone before launching.

Strategy

Manage wind, race course, current, and time evolution. Decides which side and when.

Tactics

Manage rivals, crossings, and manoeuvres. Executes strategy against the fleet.

Meteorology

Feeds strategy with the regime, the trend, and the geography of the race course.

> **ForSailors Operating Cycle:** Read the regime → Build your hypothesis → Test it on the water → Correct → Sail with conviction.

MODULE 1 — FUNDAMENTALS

The atmosphere: a thin layer of fluid

Everything that happens in the atmosphere takes place within the first **10 km of altitude** above the Earth's surface. The Earth measures 22,000 km in diameter. The atmosphere, by comparison, is an incredibly thin film — comparable in thickness to the ocean, whose deepest point reaches 11 km. This proportion has a direct consequence: the atmosphere behaves like a fluid, with currents, turbulence, and mass transitions, just like water in a river.

Thinking of the wind as flowing water is not a pedagogical metaphor — it is the correct mental model. Air has density, effective viscosity, friction layers, and flow structures. It accelerates through straits, forms eddies behind obstacles, and is constantly seeking pressure equilibrium between zones of different temperature and altitude. When we talk about the gradient wind or a sea breeze filling in, we are describing the real physics of the system: air moving like a fluid, from high pressure to low, shaped by fetch, coastline, and temperature contrast.

CORE PRINCIPLE

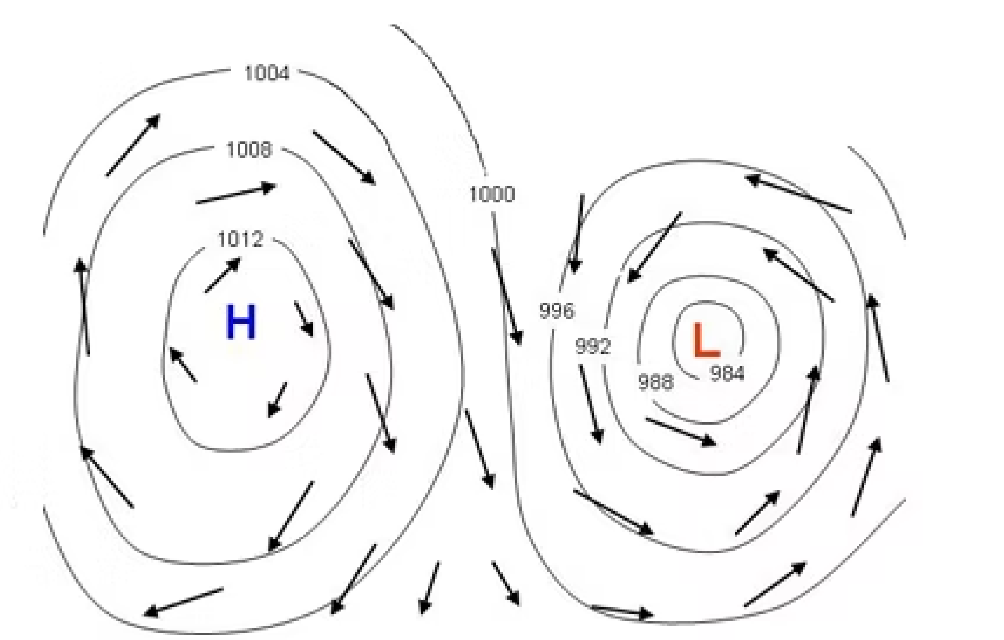
> The atmosphere is an ocean of air 10 km deep. Every gradient wind, sea breeze, gust, and shift is that fluid seeking equilibrium. Racing is reading that fluid in real time — and getting to the right side of the course before the rest of the fleet does.

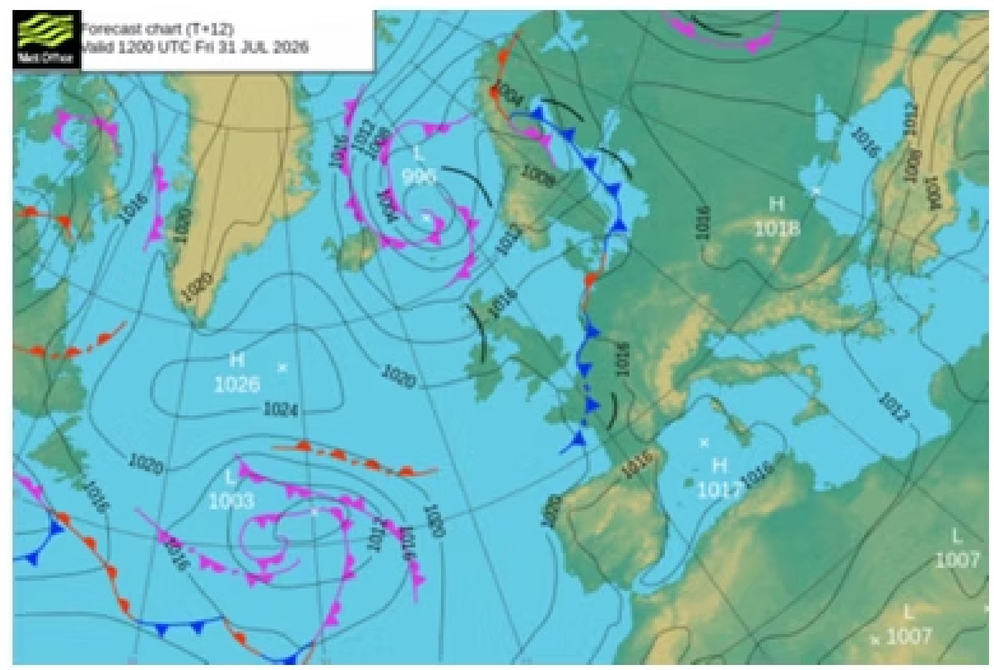
MODULE 1 — FUNDAMENTALS

Highs, lows, pressure gradient, and isobars

Atmospheric pressure is the weight of the air column above a given point. Where air converges and descends, pressure is HIGH. Where air rises and diverges, pressure is LOW. The difference between these zones is what drives the wind: air moves from high pressure toward low pressure, and the greater the difference, the stronger the flow.

Isobars are lines connecting points of equal pressure on a weather chart. Their spacing tells you everything about wind strength: tight isobars mean a strong pressure gradient and strong winds; wide isobars mean a weak gradient and light, variable conditions. In the northern hemisphere, winds circulate clockwise around highs and counterclockwise around lows — a consequence of the Coriolis effect deflecting moving air to the right.





High Pressure

Air descends and diverges. Winds rotate clockwise (NH). Associated with stable, settled conditions.

Low Pressure

Air converges and rises. Winds rotate counterclockwise (NH). Associated with unsettled, stronger winds.

Strong Gradient

Tight isobars on the chart. Large pressure difference over a short distance. Expect consistent, strong wind.

Weak Gradient

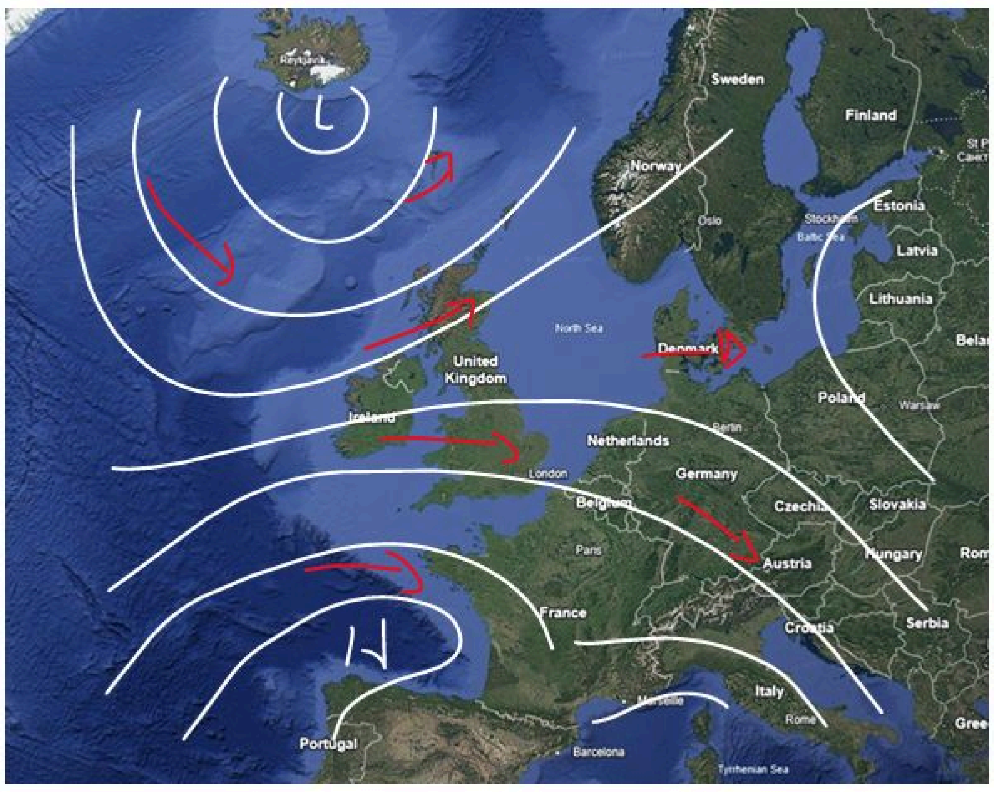
Wide isobars on the chart. Small pressure difference. Expect light, variable, thermally-driven conditions.

Operational decision: Before every race, identify whether you are in a gradient-dominated or thermally-dominated regime. Tight isobars → trust the forecast direction. Wide isobars → prioritise local thermal and geographic effects, and stay flexible.

Dominant Westerly Winds over Denmark

The most common synoptic setup over northern Europe combines a **low pressure over the North Sea or North Atlantic** with a high over the Azores extending into central Europe. The result is a predominant west to southwest gradient wind over Denmark, the UK, and western Europe — driven by the pressure gradient between the two systems.

This pattern can break down when a high pressure system shifts northward, reaching Denmark or Scandinavia. When that happens, the pressure gradient weakens, winds become light and variable, and local thermal mechanisms take over. This is worth flagging explicitly as the championship context: a heat wave over central Europe had pushed high pressure northward, generating weak gradient conditions and light winds with a much stronger sea breeze influence.



GENERAL PRINCIPLE

> Over Denmark, the dominant gradient wind comes from the southwest or west. When it weakens, the sea breeze and local geographic effects take command.

MODULE 1 — FUNDAMENTALS

Fronts and Air Masses

What is a Front?

A front is the **boundary between two air masses** of different temperature and humidity — like a layer of red-dyed warm water meeting cold blue water. The two masses do not mix easily; instead, they slide against each other, creating a sharp transition zone with distinct wind, pressure, and weather changes on either side.

Front Types & Their Effects

Warm Front

Warm air rises gradually over cold air. Preceded by high cloud, then lowering overcast, rain, and a **backing wind shift** on passage.

Cold Front

Cold air undercuts warm air sharply. Fast-moving, brings **sudden veer, gusty squalls**, and rapid clearing behind.

Occluded Front

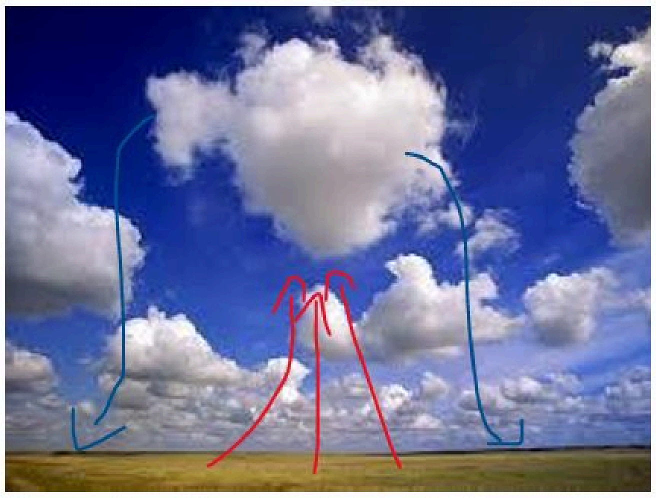
Cold front catches the warm front. Complex, slower-moving boundary — often associated with prolonged unsettled conditions and **erratic shifts**.

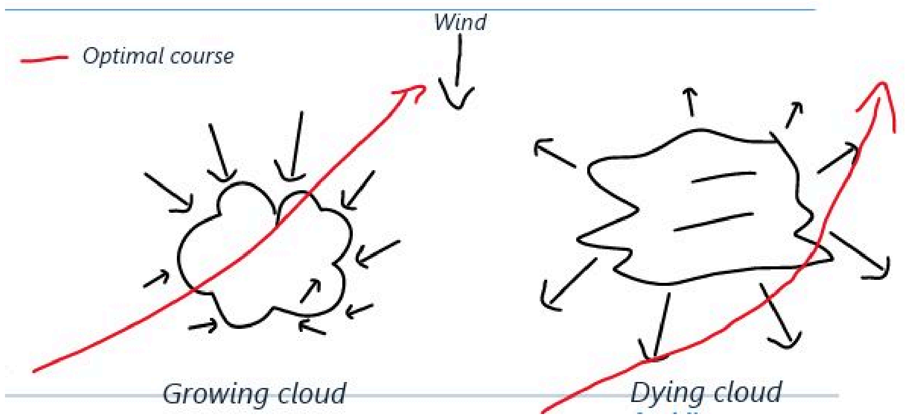
Operational decision: Check whether a front is approaching before the race. A warm front means a gradual left shift incoming; a cold front means a sharp right veer on passage — often with a gust. Positioning on the correct side of the course before the front arrives is a decisive tactical move.

How Cumulus Clouds Form

When the sun heats the surface, the air near the ground warms up, becomes less dense, and rises — just like warm water rising from the bottom of a pot. As it climbs, it cools at a rate governed by atmospheric physics. When it reaches the dew point temperature, the water vapour condenses and forms the cloud base. That base marks the exact height where the rising air has found its thermal equilibrium.

A cumulus cloud isn't just a visual phenomenon — it's the visible signal of a column of air in upward motion. Beneath that column, air is flowing inward and upward. That directly distorts the local wind field at the surface, creating convergence zones and affecting pressure gradients across the race course.





Active Cumulus vs. Dying Cumulus

Not all cumulus clouds behave the same way. Learning to read their visual state tells you whether to sail toward them or avoid them.

⬆️ Active Cumulus

Sharp, crisp edges — the cloud is still building. The thermal below it is pulling air in from the surface and driving it upward. This creates a convergence zone with stronger, more consistent pressure at the surface.

Tactic: Sail toward it, or slightly above (windward side). You are heading into the inflow — expect a lift and a pressure increase.

⬇️ Dying Cumulus

Milky, fuzzy, dissolving edges — the thermal has collapsed. The cloud is now spreading and evaporating. The column of air that was rising is now descending, pushing a downwash of air outward at the surface.

Tactic: Go around the bottom (leeward side), as you would treat a leeward mark. Sailing into it means sailing into sinking, diverging air — expect a header and a pressure drop.

APPLICATION IN AARHUS

The Aarhus bay regularly produces thermal cumulus during summer sea breezes. As you round the windward mark, scan the clouds ahead: sharp edges mean pressure — go toward them. Milky edges mean the thermal is done — avoid sailing underneath. This read can be worth multiple boat lengths on a long run or the second beat.

GENERAL PRINCIPLE

> A cumulus cloud is an operational signal, not just decoration in the sky. It tells you where the thermal ascent is happening — and therefore how the wind field is being deformed around it. Watch the fleet, watch the clouds, watch for the gusts tracking underneath them.

Cumulonimbus, Squalls and Thunderstorms

When a cumulus keeps growing for hours without anything to slow it down, it can develop into a **cumulonimbus**. These convective towers can reach 12–15 km in height, punching through the tropopause. They produce torrential rain, hail, lightning and in extreme cases waterspouts. In Aarhus, it's worth noting that this risk is secondary but real: "More typical of the Mediterranean, but possible if conditions are very unstable and the sea is warm."

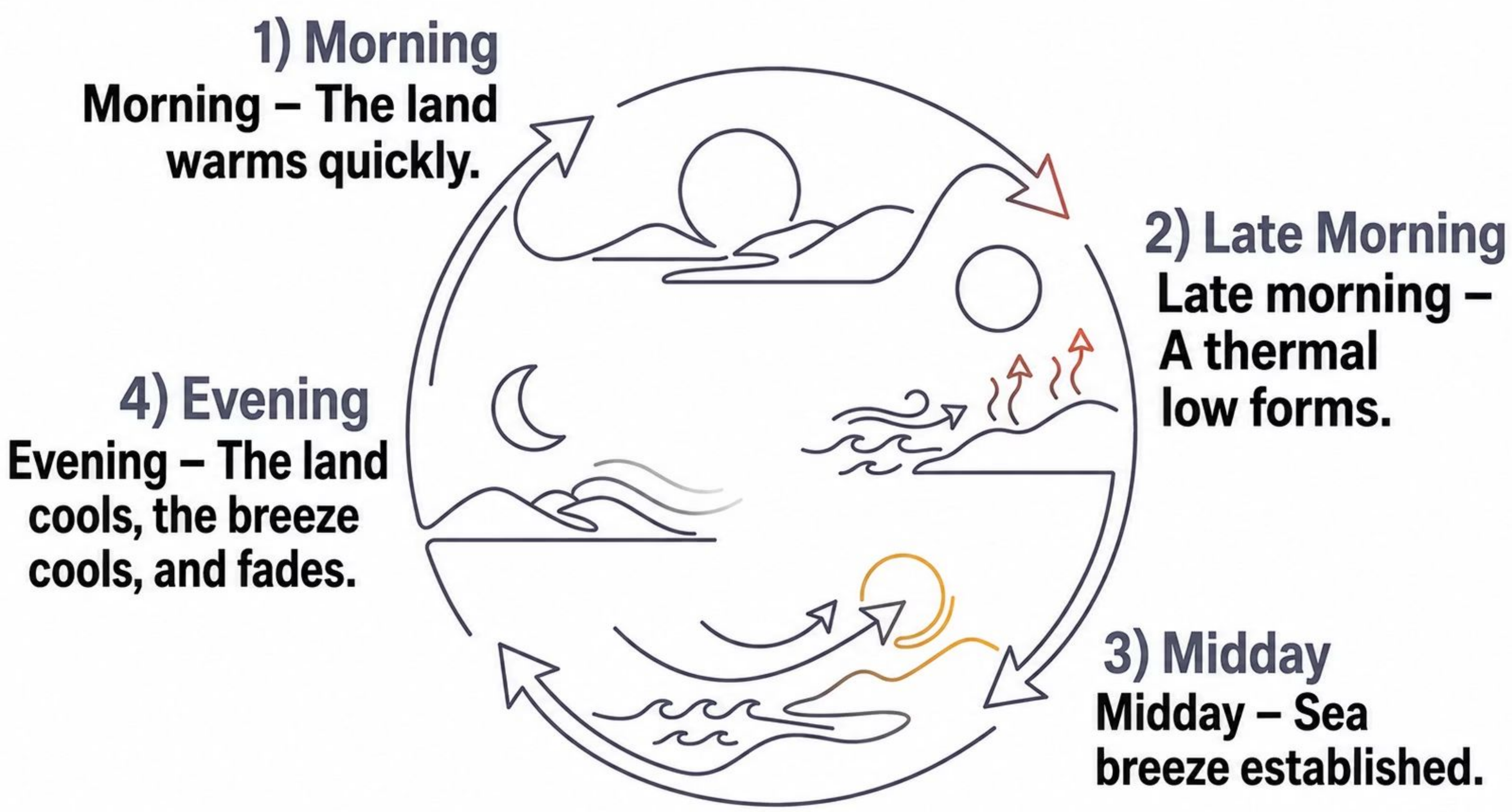
A cumulonimbus completely destroys the local sea breeze for as long as it lasts. The race committee will normally spot them far enough in advance to abandon the race. However, if there are inland cumulonimbus cells over the land that track towards the race course late in the afternoon (between 15:00 and 17:00), the sea breeze can collapse very suddenly.

OPERATIONAL DECISION

If the horizon to leeward shows a dark tower with an anvil on top, this is not a strategy call — it's a safety call. Tell your coach. Under normal Aarhus conditions, the priority is to check whether there are any cumulonimbus cells building over land in the afternoon that could move over the race course.

The Sea Breeze Engine and Land Breeze

The sea breeze is a closed-cycle thermal engine driven entirely by the temperature contrast between land and sea. As the sun heats the land surface, the air above it warms, becomes less dense, and rises. This creates a low-pressure zone over the land. Cooler, denser marine air flows in from the sea to fill the gap — that inflow is the sea breeze. At altitude, the return flow carries the warmed air back out over the sea, completing the circuit. On a well-developed summer day in Aarhus, this engine typically produces 10–15 knots of steady breeze from the sea.



Two Conditions Required

☀️ Enough Sun

The engine only runs when there is sufficient solar heating to create a meaningful temperature contrast between land and sea. Overcast days or weak radiation suppress the sea breeze entirely. In Aarhus, the sea breeze typically establishes between late morning and early afternoon on sunny summer days.

⚖️ Weak Pressure Gradient

The sea breeze is a local, thermally driven circulation. It can only assert itself when the synoptic (large-scale) pressure gradient is weak. Once the prevailing wind exceeds roughly 18–22 knots, it overwhelms the thermal circulation and the sea breeze is killed. On strong gradient days, expect the synoptic wind to dominate all day.

Land Breeze at Night

The same engine runs in reverse after sunset. The land cools faster than the sea, so the pressure gradient flips: air sinks over the cold land and flows outward toward the relatively warmer sea. This produces a land breeze — typically gentle (2–6 knots), offshore, and most pronounced in the hours before dawn. It is rarely relevant for racing but shapes the early-morning conditions before the sea breeze re-establishes.

GENERAL PRINCIPLE

> No sun, no sea breeze. Strong gradient, no sea breeze. The sea breeze is a local thermal phenomenon that only exists in the gap between those two suppressors. When both conditions are met, it is one of the most reliable and readable wind systems available to the racing sailor.

Geographic effects: the wind doesn't travel in a straight line

Wind is a fluid, and like all fluids it finds the path of least resistance. Headlands, peninsulas, valleys, buildings and curved coastlines deflect it, accelerate it, slow it down or fragment it. Understanding these effects means reading the race course before you sail it.

Acceleration and friction

As wind crosses from land to sea, it loses friction and accelerates. As a rule, it tends to shift slightly to the left during that transition.

Channelling

Valleys, roads and gaps between buildings channel the wind and accelerate it (convergence). Divergence, by contrast, slows it down and spreads it apart.

Wind shadow

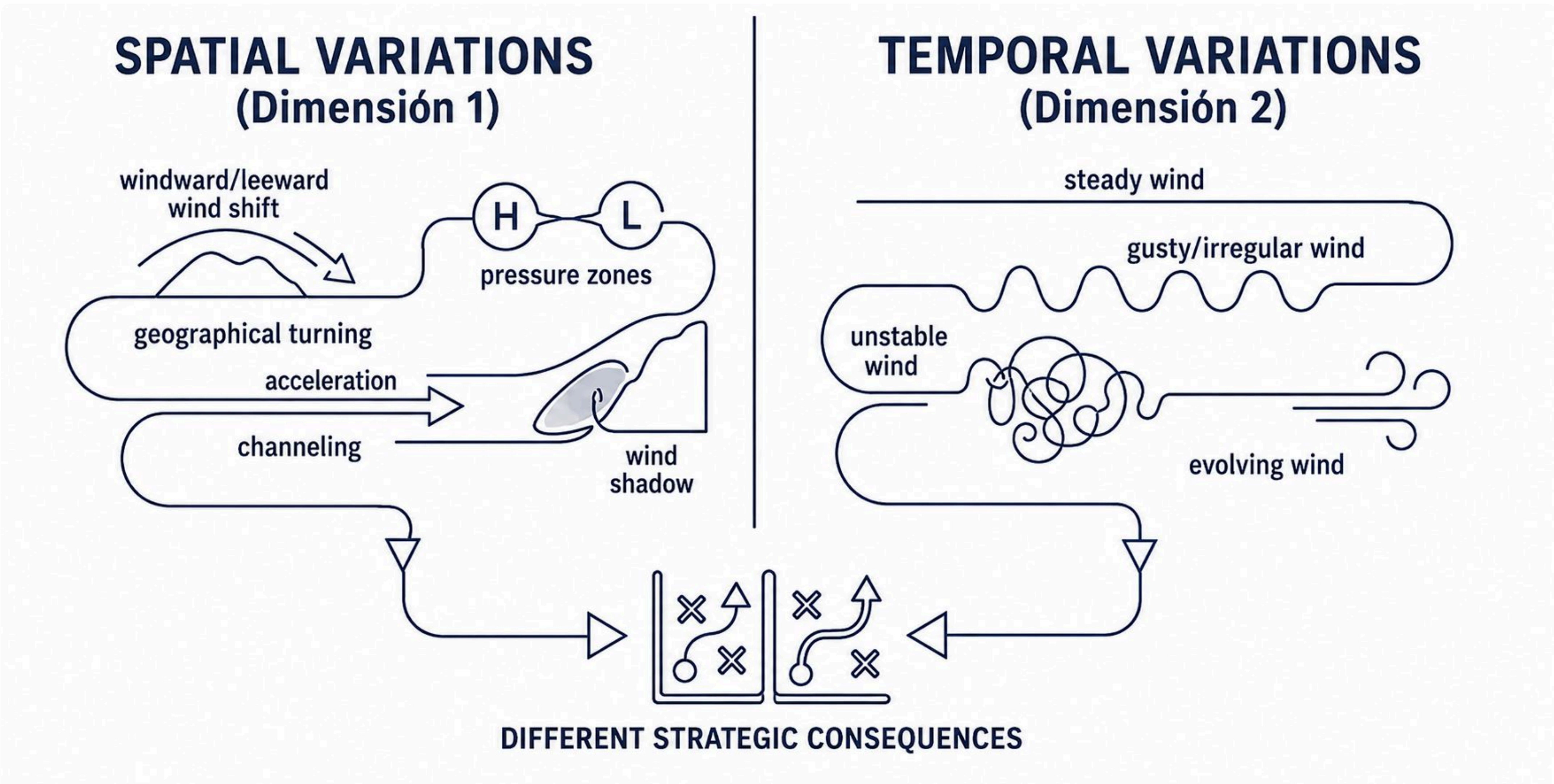
Behind a headland there is a shadow zone with light or no wind. Sailing into it can mean losing the breeze in an instant.

Banana effect

The sea breeze bends along the coastline. The inside of the curve gets a favourable shift (lifted tack). The outside can fall into the shadow zone.

OPERATIONAL DECISION

Before chasing small compass shifts, first identify whether pressure gradient, acceleration, channelling, a wind shadow or coastline geography explains what you are seeing. Geographic shifts are persistent; oscillating shifts are temporary. Don't confuse the two.



Three sailing modes: the strategy compass

The system groups all strategic sailing into three modes. Identifying which one you're in before the start is the first step of the operating system.

1

Mode 1: Persistent / Geographic

The wind is shifting persistently in one direction, or there's a clear geographic effect (headland, banana effect). One side of the race course is structurally better. Anticipate which side the persistent shift favours and get into position early.

2

Mode 2: Oscillating

The wind oscillates left-right in a predictable pattern. Establish the mean wind direction, sail the lifts and tack on the headers. The more consistent the oscillation, the more value you get from watching the compass.

3

Mode 3: Offshore / Random

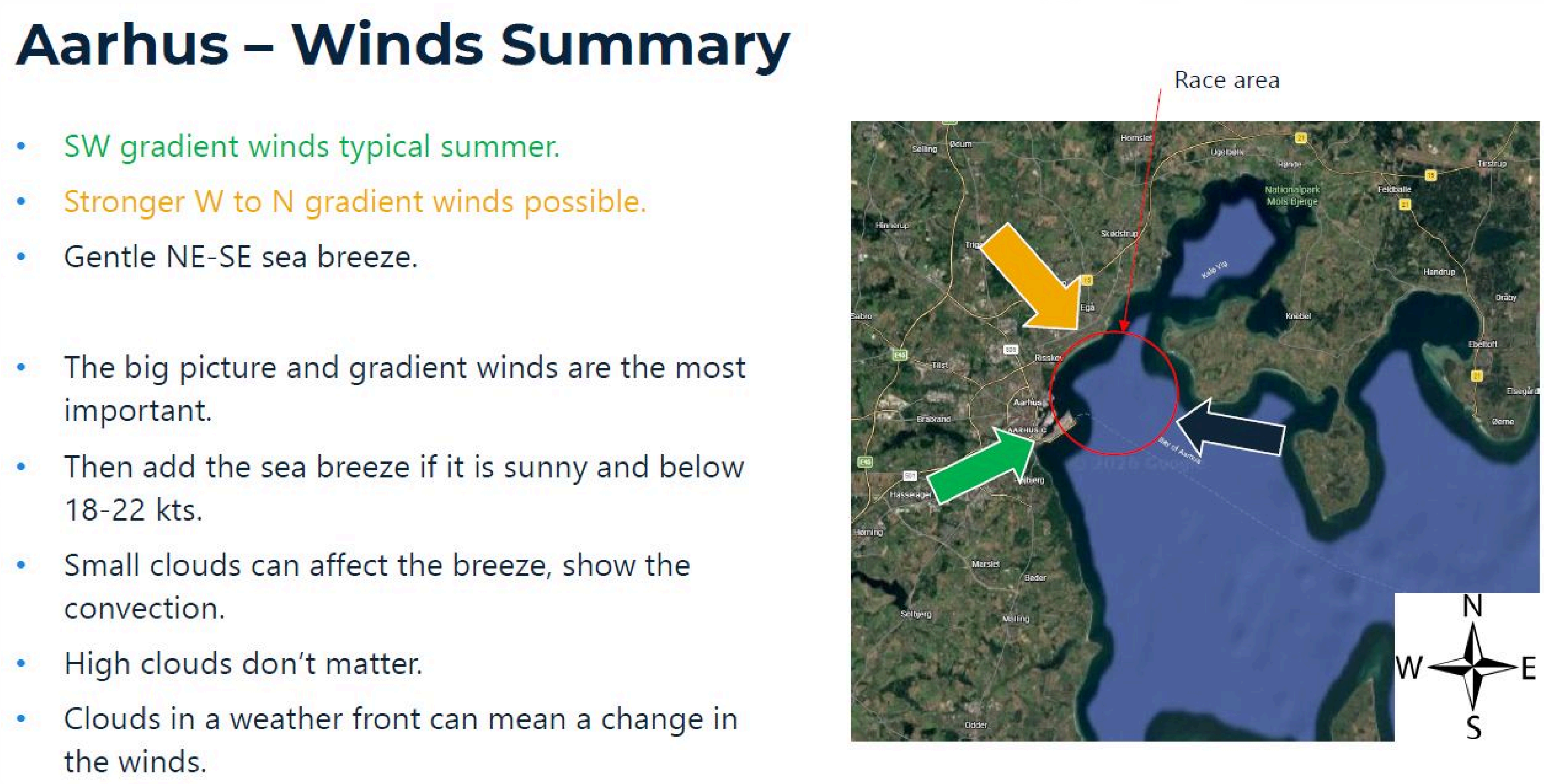
Wind coming off the land — erratic, with disconnected gusts and patchy pressure. Sail the lifted tack, link pressure bands, and prioritise your manoeuvres before the start. Keep your eyes out of the boat.

APPLICATION IN AARHUS

Mode 3 is especially relevant when the wind comes off the land (west or offshore). Mode 1 dominates with a well-formed sea breeze and an active banana effect along the coast. Mode 2 is unlikely given the geographic complexity of the bay, but can appear with a stable SW pressure gradient and limited thermal interaction.

Aarhus Race Course Profile

Aarhus sits on the east coast of Denmark. The bay is small and heavily sheltered by land on almost every side. Even from the southeast — the direction with the greatest fetch — the open water distance doesn't exceed 80 km. That has direct consequences: no swell, waves are small and local, the water is shallow (between 2 and 20 metres), and the tide is minimal, with variations of less than half a metre.



Water temperature in August is around 18–20 °C, which is enough to fuel sea breeze mechanisms on sunny days. However, the race course is so surrounded by land that local geographic and thermal effects constantly dominate over any clean synoptic signal. Sailing there has been described as a "lake" — but a lake with multiple competing wind sources all fighting for control.

Maximum Fetch

~80 km from the southeast. No swell — local chop only.

Depth

2–20 metres. Shallow water can generate short, steep chop in moderate breeze.

Tide

Less than 0.5 m range. No practical effect on racing or lay lines.

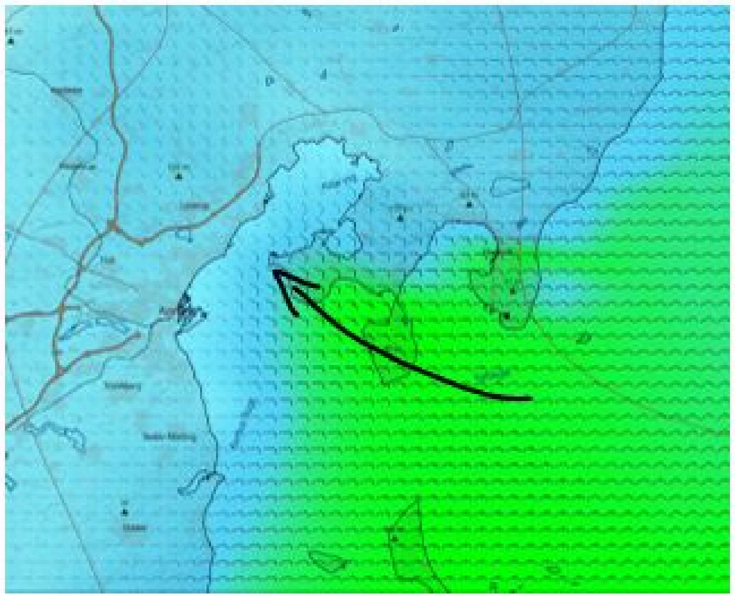
Water Temperature

18–20 °C in August. Favourable conditions for sea breeze development on sunny days.

Small Morning Breezes

Aarhus early sea breezes ~11h

Aarhus E Sea breeze banana ~16h



At 10–11 in the morning, when the sun has been heating the land for a while but the thermal cycle hasn't yet reached any real scale, multiple small-scale breezes appear perpendicular to each coastline. These breezes point inland from every shore: from the north, from the south, from the east. In the centre of the race course where they oppose each other, the wind can be extremely light.

This phase is important to recognise because it can be mistaken for a complete calm or a weak pressure gradient. In reality, the system is preparing for the next state. The sailor needs patience and fixed references to detect which local breeze is dominating at any given moment and from which direction the pressure is arriving.

APPLICATION IN AARHUS

In the first races of the day, under weak gradient conditions, land references on each side of the course are more useful than the compass for knowing whether you're on a lifted tack or a header. Establish fixed visual references before the start sequence.

Transition to the Large-Scale Sea Breeze

As solar heating intensifies through late morning, the competing small-scale breezes progressively weaken and merge. One direction wins out — typically the component with the greatest fetch and the most unobstructed access to the race course. The scattered local circulations consolidate into a single, organised large-scale sea breeze. In many locations this is a gradual process. In Aarhus, it is not.

The confined geometry of the bay means that when the sea breeze finally organises, it arrives as an abrupt jump rather than a smooth increase. The transition from confused light air to an established breeze can happen in a matter of minutes, catching unprepared sailors mid-manoeuvre.

The Breeze Front

The arrival of the large-scale sea breeze is often preceded by a visible and physical signal: the breeze front. This is the leading edge of the cooler, denser marine air mass advancing over the warmer land-heated surface air. In Aarhus it typically appears as a dark band on the horizon — a line of slightly ruffled, darker water moving toward the course. Wind speed can jump from 3 to 12 knots in a matter of minutes as the front passes. The incoming air mass is noticeably cooler and more humid than the air it replaces.

APPLICATION IN AARHUS

Visual Signal

Watch for a dark band or line of disturbed water advancing from the open part of the bay. This is the breeze front. Track its speed and angle of approach relative to the course marks.

Physical Signal

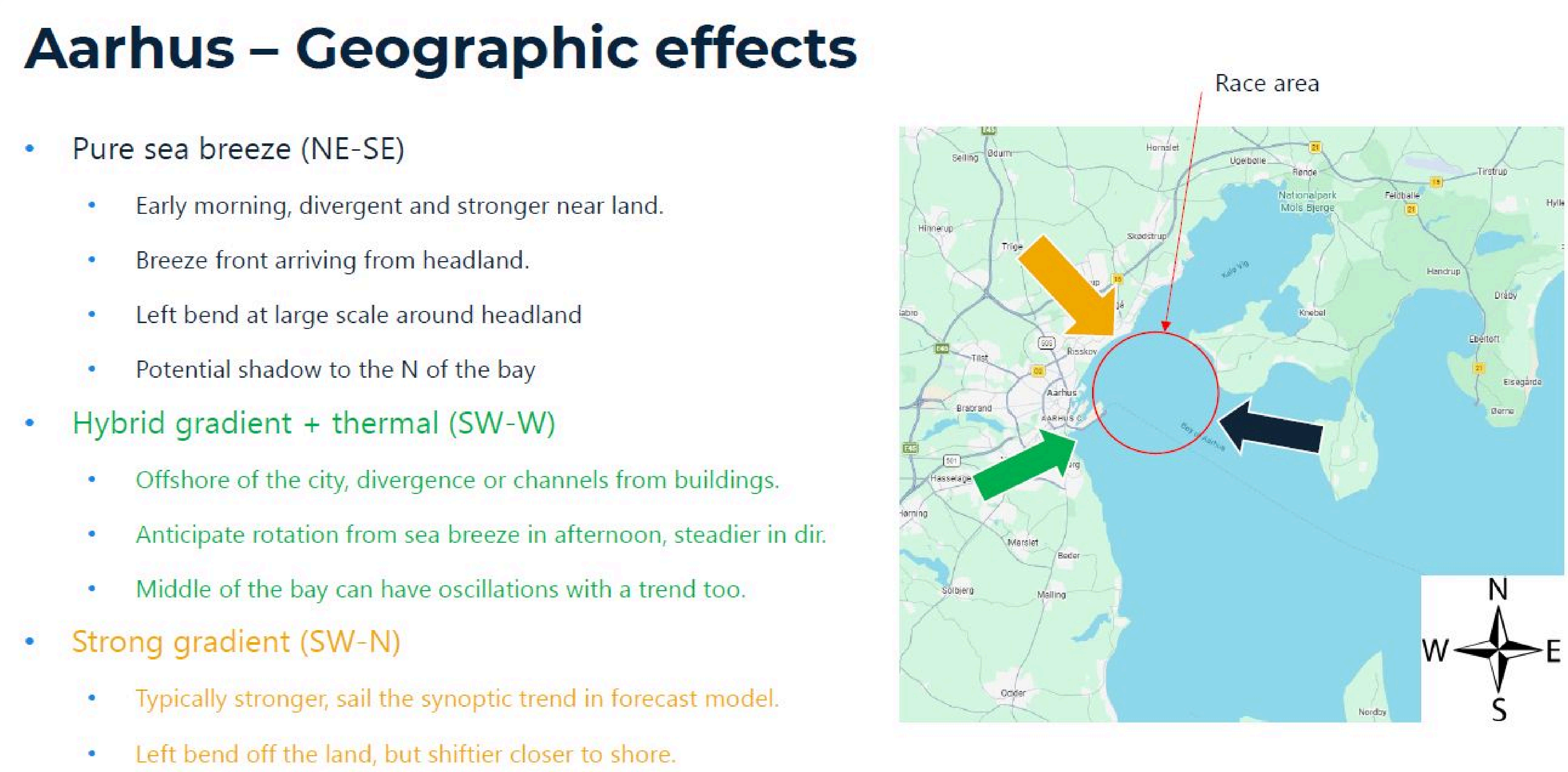
A drop in air temperature, an increase in humidity, and a sudden increase in wind pressure on exposed skin or sails. These sensory cues arrive seconds before the full wind shift hits the boat.

Decision

When the front is visible, position for the new breeze before it arrives. Identify which side of the course will be lifted first, consolidate toward that side, and be ready to tack immediately as the front passes through.

Banana curve around the headland

On the eastern shore of Aarhus Bay there is a headland that produces the characteristic **banana effect** when the sea breeze comes from the east or southeast. The air, like a fluid, wraps around the headland and arrives at the race course bent: curving toward the inner side of the bay. The result is a structural advantage on the inside of the curve, where the wind arrives on a **lifted tack**.



Sailing toward the inside of the banana curve is the correct strategy in mode 1. But there is a critical point to watch: going too far east can put you in the **wind shadow** of the headland, where pressure gradient-driven flow disappears entirely. The transition from "lifted" to "no wind" can happen within metres.

OPERATIONAL DECISION

With an easterly sea breeze: target the inside of the banana. Before you leave the dock, mentally define the boundary of the wind shadow. If the wind feels "too good" on the far eastern side, you are probably about to sail into the dead zone. Use land references to mark that limit — and don't chase the **lifted tack** past the point of no return.

Influence of the City of Aarhus on the Wind

The city of Aarhus introduces two opposing effects depending on the dominant wind regime. Understanding which effect is active — and when it transitions — is one of the more subtle edges available on this race course.

With an easterly gradient wind

Pressure cushion: the urban mass acts as a physical obstacle, creating a zone of slightly elevated pressure on the windward side. This slows the wind near the shore and can produce a persistent header for boats approaching the city side of the course.

With a pure sea breeze

Urban heat intensifies thermal uplift: the city's heat island accelerates the convective engine, pulling the sea breeze more strongly and bending it toward the city. Boats on the city side can find significantly more pressure and a lifted angle compared to the open-water side.

OPERATIONAL DECISION

Identify which regime is active before the start. If the gradient wind is dominant, treat the city side as a header zone and favour the open water. If the sea breeze has fully established, the city side becomes the pressure side — shift resources there and look for the lifted angle as you approach the shore.

Thermal Timeline: Formation, Peak and Shutdown

The sea breeze follows a broadly predictable daily cycle. Understanding that cycle lets you anticipate when the regime is about to change rather than reacting once it already has.

1

Morning (~10-11h)

Small-scale local breezes, perpendicular to each shoreline. Light and variable in the centre of the course.

2

Midday (~12-14h)

The cycle scales up. Possible sea breeze front. Rapid transition to large-scale sea breeze. Maximum acceleration and convergence.

3

Peak (~13-15h)

Sea breeze at its strongest. Up to 12-15 knots on favourable days. The banana-shaped pressure gradient is well established.

4

Afternoon (~15:30-17h)

The sun loses angle, heating decreases. The sea breeze begins to ease progressively. Watch for persistent shifts as the mode changes.

5

Shutdown

In pure sea breeze mode, shutdown can be very rapid at sunset. Don't confuse it with a temporary oscillation or a random mode shift.

OPERATIONAL DECISION

If you're in the last race of the day and the breeze starts dropping after 15:30, don't wait for it to come back. It may be the start of the shutdown. Sail more conservatively, stay away from the lay lines and keep your options open — don't get caught on a lifted tack at the wrong end of the beat.

SW Gradient + Sea Breeze: The Daily Shift Pattern

When a southwest gradient wind is present at the start of the day and the sea breeze builds through the afternoon, the two systems interact to produce a recognisable — though not guaranteed — directional drift over the course of the day.

Morning to midday: gradual right-hand shift

As the sea breeze develops and reinforces the southwest gradient, the combined flow tends to veer progressively to the right. The sea breeze component adds a southerly element that pushes the wind clockwise. The right side of the beat tends to pay as this shift builds.

Afternoon: tendency to back left

As the sea breeze reaches its peak and begins to ease, the gradient wind can reassert itself or the thermal component weakens unevenly. The wind may back toward the left again, particularly if the sea breeze starts its shutdown phase before the gradient fully takes over.

⚠ This is a tendency, not a rule. The shift pattern can be compressed, delayed, reversed or absent entirely depending on the strength of the gradient, cloud cover, timing and local topography. Never commit blindly to a side based on the time of day alone.

OPERATIONAL DECISION

In a SW gradient + sea breeze day, the right side often pays in the morning as the breeze fills in from the right. But stay alert in the afternoon: if the breeze starts to ease after 15:30 and backs left, the fleet that chased the right all day may find itself on the wrong side of the course. Keep your options open and watch for the first signs of a directional change rather than assuming the morning trend continues.

Strong West and North Winds: Fronts, Storms & Offshore Flow

When an active low pressure system passes over northern Europe, the pressure gradient strengthens significantly and the wind can come from the west or northwest at 18–25+ knots. In these conditions, interaction with the sea breeze is practically zero: the gradient wind dominates completely.

The race course will have more turbulence, especially near shore. The wind may shift as the front passes, but that shift responds to synoptic dynamics, not local effects. The operational rule is simple: sail what the model says. If ECMWF or Aladin forecasts a slow rightward persistent shift as the front goes through, that can be a valid bet if the beat is long enough.

OPERATIONAL DECISION

With a strong westerly and overcast skies: forget the sea breeze. The synoptic model is your main reference. Areas closest to shore will be more turbulent and unpredictable. Work the centre of the course or the side showing more consistent pressure according to the model.

Offshore Wind: The Most Demanding Mode on the Race Course

When the wind comes from the land — northwest to northeast in Aarhus — it arrives after passing over buildings, trees, valleys, and urban terrain. This produces a fragmented, disturbed flow that bears little resemblance to the clean gradient aloft. The result is a wind that is **erratic close to shore** and only begins to organise itself as you move further offshore, where the surface has had time to smooth the flow.

This creates a fundamental challenge for course setting. A traditional windward–leeward layout can become a dogleg course: the wind near the start line may point in a different direction from the wind at the top mark, making the geometry of the beat or run unreliable. Shifts are not strategic — they are mechanical noise generated by terrain obstacles, not by pressure or thermal gradients.

OPERATIONAL DECISION

With an offshore wind: plan more manoeuvres before the start to sample the wind at different distances from shore. Close to the beach, treat the shifts as random — do not overcommit to one side based on a single header or lift. Further out, the flow becomes more organised; link pressure gusts and look for persistent shifts that the synoptic model supports. The further the top mark, the more the offshore organised flow matters; the shorter the beat, the more random noise dominates.

Close to shore: erratic

Fragmented flow from terrain obstacles — buildings, trees, and valleys disturb the gradient. Shifts are mechanical noise, not strategic signals. Sail in random mode and avoid overcommitting to either side.

Further offshore: organised

The flow smooths out with distance from land. Pressure gusts become linkable, persistent shifts emerge, and the synoptic model becomes a reliable reference. This is where strategic sailing resumes.

Convergence, Divergence, Buildings, Boats, Ferries, Current & Chop

Beyond natural geographic effects, the Aarhus race course has man-made elements that modify the flow. The harbour buildings and city structures channel the wind into acceleration corridors (convergence) or fan it out into softened, spreading flow (divergence). The rule is intuitive: if there's a corridor funnelling wind toward the sea, it's likely a divergence that slows the flow. If there's a corner forcing two flows to converge, it's a convergence that accelerates it.

Bear in mind that large ferries and ships also generate wind shadow. If you're more than **7–10 times the height of the obstacle** to leeward, the effect diminishes significantly. A large vessel 20 m tall generates relevant shadow in the first 140–200 m downwind. In the Aarhus harbour area, this is perfectly possible during races.

APPLICATION IN AARHUS

Before the race, identify the corridors between buildings facing the sea (potential wind channels), the ferry transit zone, and the calm-water areas behind harbour structures. These effects are repeatable and can be exploited systematically — a genuine edge for the fleet sailors who do their homework.

Current, Tide, Chop and Swell in Aarhus

What NOT to expect

- **Significant swell:** Aarhus Bay is sheltered — long-period swell from the open ocean does not arrive here.
- **Constant tidal current:** The Baltic has a minimal tidal range. There is no predictable flood/ebb cycle like in Atlantic venues.
- **Long-period swell:** The fetch is too short for well-organised swell trains.
- **Deep water effects:** The bay is shallow — wave behaviour differs from offshore deep-water venues.

What CAN appear

- **Wind-driven current:** After sustained wind, surface drift builds in the direction of the wind. Can reach meaningful speeds after several hours.
- **Drainage current:** Freshwater outflow from the land can generate a slow but consistent current near the shore, especially after rain.
- **Short chop:** With onshore or cross-shore winds, a steep, short-period chop builds quickly in the bay. Boat-handling in these conditions is critical.

> **Borja's observation:** In Aarhus, current measured at approximately **10–13 metres per minute** — enough to shift the layline calculation by several boat lengths on a long beat. Ignore it and you may find yourself pinching at the mark or taking an unnecessary extra tack.

OPERATIONAL DECISION

Before racing, look at the water surface for streaks, foam lines, or debris movement to estimate drift direction and speed. If wind has been blowing consistently for more than 2–3 hours, assume wind-driven current is present and adjust laylines accordingly.

OPERATIONAL DECISION

In choppy conditions, prioritise boat speed over pointing. Short chop in Aarhus can be particularly punishing for sailors who over-sheet and stall. Sail slightly freer, keep the boat moving, and recover height gradually.

MODULE 3 — MODELS & FORECASTING

What is a weather model

A weather model is a computer program that divides the world into three-dimensional boxes and solves the equations of fluid dynamics to calculate what is going to happen in each box over the coming days. Every national meteorological agency runs its own model with its own name, its own grid size, and its own coverage area.

The number that comes with the model name indicates the **size of each box**: ECMWF 7 km means each calculation cell covers 7 km × 7 km. ALADIN 2 km means cells of 2 km × 2 km. If your race course is 1 km long, a 7 km model calculates a single wind value for that entire area. It cannot resolve local differences within the course. It can give you the correct picture of the overall regime and the dominant direction.

> The model cannot see what is happening in your corner of the race course. It can tell you whether the gradient wind is coming from the SW or NW and whether there is a front. It cannot tell you whether the windward mark has more pressure than the start line end.

Real grid limitations: what the model doesn't see

What the model cannot resolve

- **Headland banana effect:** a 500 m headland bending the wind around its lee side is invisible to a 7 km grid — the entire feature fits inside a single calculation cell.
- **Harbour building corridors:** channelling or blocking effects created by buildings and breakwaters cannot be calculated at this resolution.
- **Wind shadow vs. open water:** the model cannot distinguish between a wind shadow 200 m wide and the open water immediately beside it.

What the model IS reliable for

- **Synoptic picture:** the overall pressure pattern, dominant wind direction, and the position of fronts and high-pressure centres.
- **General shift trend:** whether the wind is expected to back or veer through the day, and the approximate timing.
- **Cloud cover and precipitation:** large-scale cloud fields, rain bands, and clearing sequences.

OPERATIONAL DECISION

When the model shows a shift, always ask **why**. Is it a sea breeze overtaking the gradient? Is it a front passing through? Or is it simply a boundary between two adjacent grid cells producing a numerical artefact — *grid noise*? The answer changes how much confidence you place in the forecast and whether you expect the shift to be sharp or gradual, persistent or fleeting.

Recommended Models & Daily Consultation Routine

ECMWF (7 km)

The global reference model. Excellent for the synoptic picture: dominant gradient wind direction, pressure, fronts, general cloud cover. Reliable several days out. Use it to understand the overall regime for the day.

ALADIN (2 km)

Fine-mesh regional model. Better resolution for local effects and sea breeze. Less reliable several days out due to the complexity of the calculation. Use it for the detail of the following day.

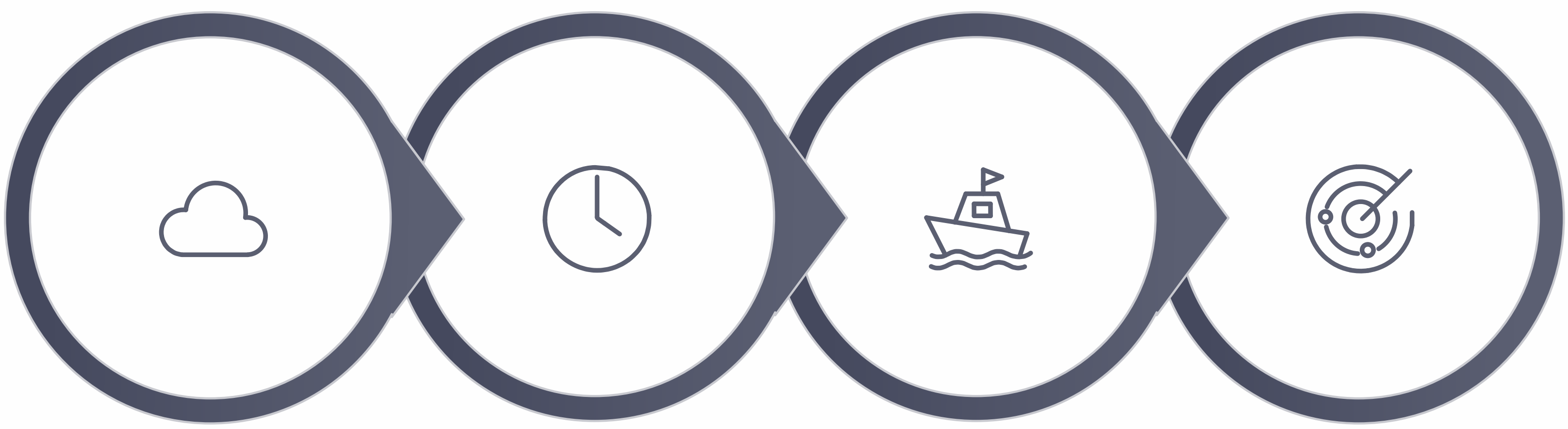
UKV (UK Variable)

The Met Office model. Especially recommended for northern Europe: "The climate of Denmark is very similar to that of northern UK, and this model is optimised for it." High resolution with good capture of coastal effects and headland shifts.

GENERAL PRINCIPLE

All forecast apps (Windguru, Windy, PredictWind) display the same physical models. What changes is the interface, the pricing, and how the information is presented — not the underlying physics. Choose whichever feels clearest to you, but make sure it gives you access to ECMWF, ALADIN, and UKV.

Daily Model Consultation Routine



Night Before

Race Morning

On-Water

Real-Time

Check forecasts twice: the night before to understand the overall regime, and again on race morning for the detail. If the two checks tell a consistent story, confidence is high. If they diverge, treat it as a flag and increase your observational alertness on the water.

CORRECT APPROACH

Start with the **surface pressure chart** to understand the gradient wind. Then check **cloud cover** to assess sea breeze potential. Then look at **radar** for any convective activity. Finally, cross-reference **weather stations** near the race area for ground truth. Each layer adds context to the one before — don't jump straight to the wind speed number.

OPERATIONAL DECISION

If the model shows 18 knots but you have no context, that number is almost meaningless. Is it gradient wind or sea breeze? Is it building or dropping? Is it from a direction that funnels through the harbour entrance? The number only becomes actionable when you understand the mechanism producing it. Don't panic at 18 knots — ask *why* 18 knots, and *when*.

Why the model shows a shift: the key question

The most common mistake when reading a forecast is seeing "wind shifts right at 14:00" and treating it as a direct tactical signal — go right after 14:00. Before that signal has any value, you must ask why the model is showing a shift. The mechanism behind the shift completely changes how you respond to it: whether it will be sharp or gradual, whether it will be persistent or fleeting, and how much confidence to place in the exact timing.

Thermal Shift

The sun heats the land, the sea breeze locks on, and the wind progressively clocks right through the afternoon. Real and progressive. Anticipate the right side during the central hours of the day. The shift will be gradual and sustained — it rewards early positioning.

Frontal Shift

A front is passing through, producing a persistent global shift across the entire area. Identify the phase — pre-front, at passage, or post-front — and anticipate the post-front direction. The shift can be sharp and decisive. The new direction is likely to hold for the remainder of the day.

Grid Noise

A model artefact at the boundary between two calculation cells — no real physical phenomenon exists. The shift will not materialise on the water. Trust direct observation over the model number. Sail in random mode and respond to what you see, not what the forecast says.

Pre-launch hypothesis: the internal briefing

Before launching, the sailor and coach need to have built a working hypothesis together. Not an exact forecast, but a mental model of the day: what regime is likely, why it's happening, what could change it, and how it will evolve hour by hour. That hypothesis is what drives decisions on the water — it doesn't replace them.

01

Pressure gradient

Where is it coming from and how strong? Is there a front on the way? Check the surface pressure chart and isobars.

02

Sun and temperature

Is there enough heating for a sea breeze? What's the cloud cover forecast? Air temperature vs. water temperature?

03

Sea breeze potential

Is a sea breeze actually possible today? Or is the gradient wind too strong, or the sky too overcast to trigger it?

04

Active geography

Given the expected regime, which geographic effects will dominate? Headland acceleration, offshore flow, channel convergence?

05

Current and hourly evolution

Is there residual current from previous days? What time are the regime shifts expected — and will the fleet be on the beat or the run when they hit?

On-water validation: testing your hypothesis

The hypothesis is built on shore. Validation happens on the water. Before the first gun, you have a window to test the key assumptions of your briefing against direct observation. The goal is not to confirm your hypothesis — it's to find the earliest possible signal that it may be wrong.

Fixed references and compass maxes.

Identify fixed references on shore and take compass readings of the wind angle. Note the max lifts and headers. This gives you the oscillation band before the race starts — the numbers you will use to judge every tack decision upwind.

Windward boats and pressure bands.

Look upwind. Are there boats already sailing in more or less pressure? Is there a visual dark patch indicating a puff moving down? Reading the water surface and other boats before the start gives you real-time pressure mapping the model cannot provide.

Cloud cycle and distance to shore.

Is the sea breeze cloud forming? At what distance from shore is the cumulus line sitting? This tells you whether the thermal is already established or still building — and how long before it reaches the race area.

Live current test.

Drop something in the water — a bottle, a wrapper — and watch which way it moves. Model current predictions are often coarse. A live test at the race venue gives you ground truth for the set and drift you will actually experience on the course.

Decision Matrix by Wind Regime

Each regime has its own course logic. Identify which one you're dealing with each morning and apply the corresponding mode.

Regime	Key Signal	Mode	Operational Decision
Pure sea breeze	Weak pressure gradient, clear sun, visible sea breeze front	Mode 1: banana + inside the curve	Sail the inside. Watch the shadow. Anticipate the late shut-down.
SW gradient + sea breeze	Stable SW gradient wind, partial sun, slight persistent right shift during the day	Mode 1/2 hybrid: right-hand bias + oscillating shifts	Stay right during the day. In the afternoon, be ready to come back left.
Strong westerly / offshore	Gradient >18 kt, overcast sky, no thermal interaction	Mode 3: random mode, link the gusts	Eyes out of the boat. Sail the pressure, not the side.
Easterly with cloud cover	E component, cloud cover limiting sea breeze, partial banana effect	Mode 1/3: banana active but unpredictable	The most unpredictable regime. Banana rules apply but validate constantly. Don't trust the eastern end.
Front / instability	Vertical clouds, falling pressure, possible squalls	Mode 1 post-front: persistent shift after passage	Identify which side of the front you're on. Anticipate the persistent shift. Don't over-manoeuvre during the passage.

West scenario: pressure distribution across the bay

With overcast skies (no sea breeze)

With a gradient wind from the west and overcast skies — no sea breeze contribution — the bay tends to show more pressure (more wind) toward the outside, on the left-hand side as you beat toward the windward mark. The flow comes off the land, organises itself as it moves away from the coast, and arrives cleaner on the outside of the bay.

Borja confirmed from the water that with this westerly gradient at 12–14 knots on cloudy days, there is more wind on the left side going out toward the outside of the bay: "When we tack off the inside and come out to the outside for the second beat, the wind is stronger going left."

With sun and thermal contribution

If the sun is heating the land and there is a sea breeze contribution, the pattern can be modified or reversed. Urban heating can draw the sea breeze toward the city and redistribute pressure differently, potentially reducing or cancelling out the outside advantage.

Worth noting: if a sea breeze is running and the sun is warming the land well, it can add knots and nudge the breeze slightly right on a westerly day — and that effect can disappear again as conditions change.

ON-THE-WATER OBSERVATION

The observation of more pressure on the outside in overcast conditions is a concrete measurement Borja took during the westerly days before the championship. *It is not a permanent law of the race course: it depends on the regime of the day.* Validate it each morning with a pressure and current check before the first race.

ForSailors — Your Regatta Experts

Contact website

Visit www.forsailors.es/contacto

Or

Message us on WhatsApp!

Instagram

ForSailors (@for_sailors) • Instagram profile

16K Followers, 3,011 Following, 220 Posts – See Instagram photos and videos from ForSailors (@for_sailors)