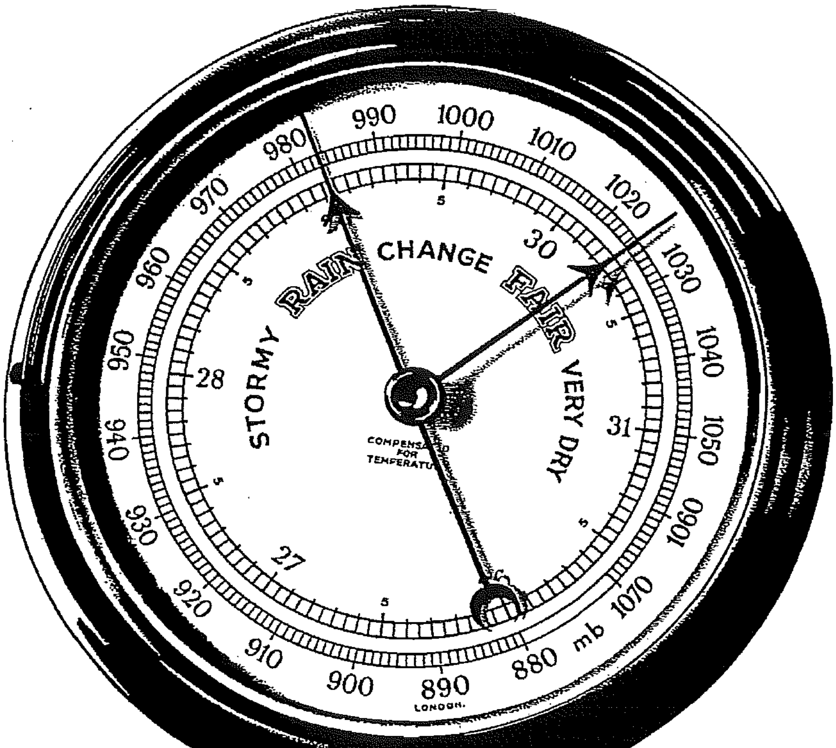
# BASIC WEATHER FORECASTING



## BASIC WEATHER FORECASTING

For basic weather forecasting at sea, you need only log the wind and pressure, and keep an eye on the clouds.

**Pattern and chaos**
Clouds come in all shapes and sizes, and are formed in classic fashion when the four "primeval elements" combine, namely fire, earth, air and water. Sunlight (fire) striking our planet is turned into heat, which turns surface water into vapour. The variegation in heating causes some areas of ground-heated air to expand faster than others, causing evaporated water to bubble upwards into the cooler air aloft, making clouds. Clouds (and rain) are sculpted by wind to form random patterns in a stuttering, turbulent fashion — a mixture of pattern and chaos.

**Moisture and mugginess**
When sunlight travels through the air, nothing much happens. However, when it hits something opaque, such as the surface of the earth or a body of water, then some of the light energy is converted into heat energy and absorbed as rising **temperature** (the vibration of the molecules). This allows molecules of water to energise themselves enough to break free from the surface tension and float into the air ... a process called **evaporation**. These water molecules floating around in the air are collectively called water vapour, or **humidity**, and they are the fuel that energises our weather. Winds conveying moist air from one part of the planet to another can be thought of as fuel lines.
There is a limit to the total number of water molecules that can be absorbed by the air, and this limit depends on the air's temperature. Near sea level (1000 hPa), a kilogram of clear air at zero Celsius can only "hold" 4 grams of water vapour, at 10 degrees it can hold 8 grams, 20 degrees 15 grams, and 30 degrees 28 grams, so there is almost a doubling of water vapour capacity in the air every time the temperature rises just ten degrees. Once a sample of air can no longer absorb any more with water molecules it is said to be **saturated**, and its temperature is then at what we call its **dew point**. Another way of measuring this moisture is the **relative humidity**, which is the ratio of its current number of water vapour molecules to the total number it has when it is saturated.

**Cooling air makes clouds and rain**
Clear air is unsaturated. When air cools the water vapour it contains remains the same and so its relative humidity rises. When the air sample's temperature cools down to its dew point, its relative humidity reaches 100% and the air becomes saturated. Any further cooling means that the air becomes **supersaturated**, and some of those water molecules will no longer have enough energy to hang in the air. They drop back into liquid form in a process called **condensation**, releasing some energy as they do so — the same amount of energy that was absorbed when the molecule changed from a liquid to a vapour — and this energy is absorbed as heat to excite the surrounding air molecules. There is a catch: the water liquid falling out of the open air usually needs some "encouragement", which it gets when it touches something solid, such as bits of smoke or dust or even sea salt (thrown into the air whenever a wave rolls or breaks); these are called **aerosols**. When a whole bunch of water molecules turn to water liquid on an aerosol, we have a cloud **droplet**. These droplets have no problems floating in thin air; there is normally

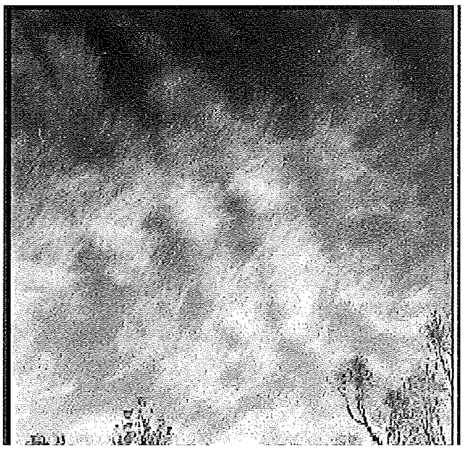
around a billion of these to every cubic metre of cloud, enough for a thousand raindrops. When this happens, the raindrops falls out of the sky in a process called **precipitation**. The simple formula for making rain is to take moist air and cool it.

**CLOUDS**

They come in many shapes and sizes but the five main words we use to categorise them are (Latin):
Cirrus = hairy Cumulus = heaped
Stratus = flat Alto = middle
Nimbus = grey

**Cirrus, Ci = ice clouds**

Highest of all clouds, wispy, made of ice, may be contrails about.
If these clouds increase and the barometric pressure falls steadily, then we have signs of an approaching front or depression.



If these clouds become bumpy and rippled (**Cirrocumulus, Cc**), this is a sign that there is a lot of turbulence aloft.
If Ci clouds flatten out and cover the sky so that the sun (or moon), when viewed through this veil of cloud, appears to have a halo around it (**Cirrostratus, Cs**), then this is a sign that something over the horizon has been producing thunderstorms.

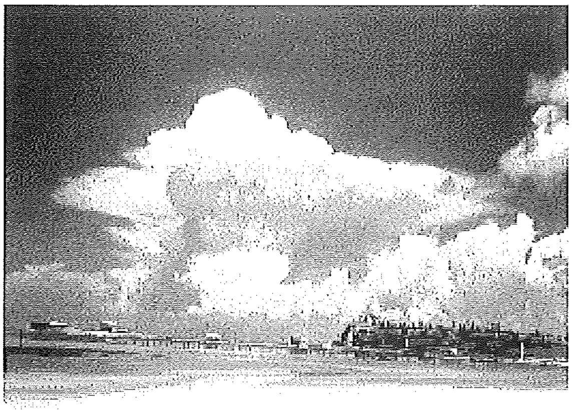
**Cumulus, Cu = unstable**

Puffy, dense with sharp outlines, a dark base and a rounded top.
Cumulus clouds indicate that the air is able to support bubbles of rising air that defy gravity. This environment also accentuates down-motions in the air. Such an environment is called **UNSTABLE** and is found in and around LOW PRESSURE regions, or where the isobars are curving cyclonically. Another sign of an unstable environment is vertically rising funnel smoke.

• If cumulus clouds are detached and no taller than their width, expect continuing fine weather.
This is normally the case in the TRADE WINDS where often they are lined up by the wind into "streets", with more wind between them than directly under them.

• If the clouds start to grow and become taller than their width, treat this as a sign that they may build to showers.
A shower cloud is a mature cumulus cloud, with a downdraught balancing its up-draught. If the up-draught of a cumulus cloud penetrates high enough aloft, the top of the cloud turns into an "ice factory" which converts most of the cloud droplets into ice. This immediately falls out with a squally downdraught, feeding a massive

downpour, sometimes with thundery discharges or hail, or even a tornado/waterspout. When this stage is reached, the cloud has an anvil-shaped head and is called **Cumulonimbus, Cb**.
The squall wind originates from the top centre of a thunderhead, whooshing downwards with the wind then fanning outwards well ahead of the rain. **So beware in the case of a steady breeze blowing towards a developing shower — you may be in for those severe gusts that come rushing out ahead of the rain.**



• Cumulus-looking clouds in the mid levels are called **Altocumulus, Ac.**
If these look like the battlements of a tower, they can be taken as early signs of thundery weather within 12 hours.

**Layered clouds = stable**
Layered clouds are given the suffix "stratus" (flat), and a prefix describing their height or character.
CIRROSTRATUS — High and icy
ALTOSTRATUS — Middle levels
STRATUS — Low levels / touching the ground
NIMBOSTRATUS — producing rain, multi-levels.
They indicate that the air is resisting the up-and-down motions found in cumulus clouds. Such an environment is called **STABLE** and is found in HIGH PRESSURE regions, or where the isobars are curving anti-cyclonically. Another sign of a stable environment is flat or downward-going funnel smoke.

**Stratocumulus, Sc** is the name given to the deck of low clouds formed by the wind blowing over the ground. The moisture, which feeds these clouds, is mixed upwards from the surface and turns to cloud when the air aloft is cool enough. The cloud deck is usually of limited vertical extent because of a layer of warmer air above it. Such cloud decks are often found within the anticyclones that migrate across the subtropics. The rolls seen within these clouds are formed by ripples in the wind

**FOG**
Fog is nasty stuff, especially when encountered near a coastline. With the increasing number of craft using GPS for navigation, many of these may simply head for the main local waypoint on a foggy day. This actually increases the chances of collision. Fog is more challenging than a gale for a day skipper to handle, and harder than a gale to forecast. Unlike a gale, fog tends to form over some areas and not others when conditions are right for its formation. As far as the skipper is concerned, things get tricky as soon as the view of landmarks and/or navigation lights becomes blurry, so

that technical definitions are rather meaningless. However, as far as a weather forecaster is concerned, the word “fog” is used when visibility is less than a nautical mile (for aviation, it is less than a kilometre). “Mist” is the term sometimes used for visibilities somewhere between 1 and 2 kilometres (or nautical miles), but in New Zealand the term “poor visibility” means obscuration of less than 3 nautical miles, and fair visibility means obscuration below 6 nautical miles.

Coastlines attract fog, and fog may form along a coast when air remains clearer offshore. Reasons for this are: the slightly cooler seas near the outflow of rivers; the forced interaction of sea currents along a coastline; and the coastal hills lifting and thus cooling the onshore wind flow. Then again, sun-heated land ensures that fog clears fastest over land and slowest offshore.

If caught in fog, **check** if the extent of it is mentioned in your weather forecast, **avoid** the major shipping lanes, and **seek the heat.**

**Fog-making recipes**
Basically, take moist air near the ground and cool it. There are several "flavours":

**1. Radiation Fog**
This is so called because the cooling is done by loss of ground heat via radiation to a clear night sky.
Since the sea surface temperature does not drop much from overnight cooling, radiation fog is a land phenomenon. It is a hard recipe to get right. If the sky is cloudy, conditions are not right for much radiation cooling. You need the right ingredients: usually a swamp, river, estuary or lake supplies the moisture, and aerosols can be supplied near a coastline by salty air which is richest near a surf beach, or by dust and pollution trapped in a dense layer of ground air over a city. The wind movement (mixing) has to be just right — too little and all you get is dew or frost; too much and the turbulence lifts the condensed air into low cloud rather than fog. About 5 knots is perfect. The source of the radiation fog is the area where moist air moves over cold ground. The formed fog can either stay there or drift elsewhere (sort of becoming advection fog), maybe across an estuary/harbour and out to sea.

What to do? If you are in a harbour on a foggy winter's morning and the air temperature is below the local sea temperature, then you are in radiation fog. Remember the rule given above — "seek the heat". You can either wait until the sunlight is strong enough to warm the ground air above its dew point, or you can move offshore away from the source of this fog.

**2. Advection Fog**
This is so called because it is formed by the movement (advection) of air.
This sort of fog is easier to make than radiation fog, but the ingredients are only occasionally available on this planet. You need to have a wind, which is moving ground air from the tropics towards the poles over a long straight uninterrupted sea track. The mixing wind needs to be enough to shake the air layers near the ground but not enough to stir in the drier air aloft (which will disperse the fog) — shaken, not stirred, just like a James Bond martini. When the air encounters a sea surface temperature lower than the air's dew point, it will cool and condense into sea-hugging fog. This fog will continue until something changes. Usually you have to wait for a neighbouring weather system to

encroach on the advection fog and change the wind direction (shorten the length of sea it tracks over). If the forming wind becomes more turbulent, this may help dispense the fog, but the wind speed can increase to strong sometimes and the fog still remains as shaken, not stirred. SPRING is the season for advection fog, with cool seas and increasing air temperature.

What to do? If the sea temperature is cooler than the air's temperature (or dew point) and you have encountered fog at sea in a wind blowing in from the tropics, then you are in advection fog. In this case, "seek the heat" may be hard to do. At sea, the warmer sea temperatures you need to reach may be hundreds of miles away, so check the weather forecast for the extent of the fog. Maybe there will be some warmer conditions near the coastline of sun-heated land. Usually you will have to wait it out for the wind direction to shift.

**MORNING WIND CHECK**

Land cools at night, and wind loses touch with the cool ground, so that the surface breeze becomes light and variable by morning. If there are any low clouds around, take time out to watch them. Their movement is due to the wind in the free (uncooled) air, and this is the wind that is blowing over the open sea. It takes practice to judge speed and direction from watching low clouds.

**LISTEN TO THE WAVES ... *Feel the beat***

The beat of the incoming ocean swell onto the shore or a reef (or the pattern of slap against your boat at sea) is determined by several factors:

- the speed of the generating wind
- the duration of this wind (how long it blew)
- its fetch (distance of wind across water)
- the distance that the waves have travelled
- local tides (or currents) and water depth

Waves generated by the wind at hand are called **sea waves** — sometimes referred to as wind waves or "sea". They are reasonably random and usually have a short period of less than seven seconds. Try and ignore them when listening to the beat.

**Swell waves** are the ones that have had time to rank themselves into order. They have been generated by the wind "over the horizon" and move away from their generating area in great-circle paths at about 300 to 500 miles per day. They usually have a period of more the seven seconds.

Strong winds generate a spectrum of swell waves, but those with the **longest** wavelength travel the **fastest**, moving out well ahead and acting as a herald for the storm. A normal beat is about 10 per minute (period of six seconds), but if this slows to six per minute (period of 10 seconds) then there are strong winds about.

**A change in the swell pattern could be the FIRST sign of an oncoming wind change ...
or it may be caused by nearby land**

# How to use your barometer

That barometer you got from Aunty last Christmas can be put to use as an onboard weather forecaster. OK, all it does is read air pressure, or the weight per unit area of the column of air above it, but by following these readings, you can tune into the vibrations of the weather pattern as it changes.

**How does it work?**
Your barometer is most likely an aneroid (= without fluid) and contains a partial vacuum in a metal cell. The size of this airtight cell varies with changes in the surrounding air pressure, and these variations are passed on to an indicator needle by a series of levers. It is all mechanical, so no batteries are needed.

**Why measure pressure?**
Pressure ... why is it so important? Because imbalances in air pressure cause wind and weather, and **changes** in the weather can be forecast by tracking **changes** in pressure.

**What the words mean**
Most barometers have a scale with numbers such as 1015 on the outside. This refers to the air pressure in hectoPascals (hPa) or millibars (hectoPascals is just a different name for millibars). A hectoPascal is one hundred Pascals, and a Pascal is the metric unit for pressure. Other pressure units are inches and millimetres of mercury. They refer to the height of mercury, which can be supported by the air pressure. To convert a pressure reading from hectoPascals to **inches**, divide the hectoPascals by **33.86.** To convert from hectoPascals to **millimetres**, multiply the hectoPascals by **0.7501**.
Many barometers have words such as "Stormy" for low pressures (980 to 1000 hPa) and "Dry" for high pressures (1020 to1030 hPa). These words are at best only a first guide to the weather. They date back to Vice-Admiral (Royal Navy) Robert Fitzroy (1805–65).

**Where to put it?**
Anywhere that is most convenient. However, when deciding where to put your barometer, there are places that you should **avoid...**
**Avoid** placing a barometer in draughty places, such as near a door. In such places the air pressure is too variable.
**Avoid** direct sunlight on a barometer. This will warm and expand the metal cell, causing a false recording of falling pressure. For the same reason, do NOT position your barometer near a heater.
**Avoid** placing a barometer in a well-sealed or air-conditioned room. Such places do not respond well to changes in pressure.

**Will it rain? Tap the barometer!**
It is OK to tap the outer glass of the barometer (firmly but lightly). When you do so, you shift any stickiness from the mechanical linkage to the measuring needle. The resulting slight movement indicates whether the pressure is rising, steady, or falling. If the measuring needle goes to the left, there has been a drop in pressure recently. Several things can cause this:

- an approaching low pressure system (marked as an L on a weather map
- the air is getting warmer (and less dense)
- an increase in the moisture or cloudiness in the air (YES — damp air weighs less than dry air!)

- a decrease in the amount of air above (this happens when rising air is removed by strong winds aloft faster than it can be replaced)
- the time of the day (this is called diurnal pressure change and is discussed later).

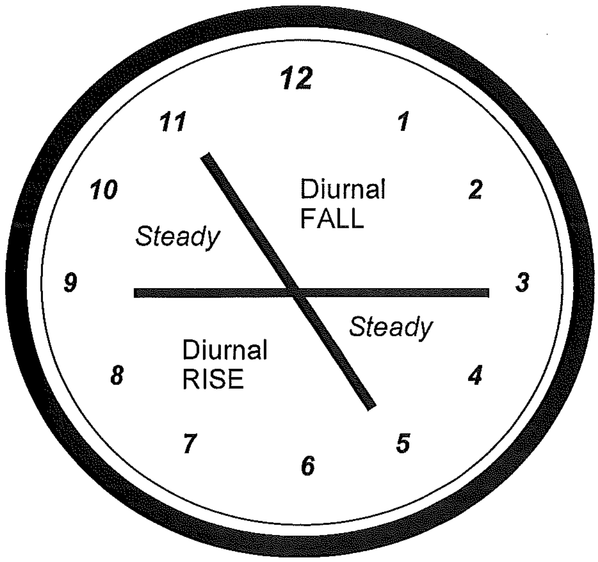
A tap on the barometer measures all these in one go.

> As a rule of thumb,
> a sustained **DROP** in pressure
> is a sign of **more** chance of rain;
> a sustained **RISE** in pressure
> is a sign of **less** chance of rain.

If a tap on the barometer results in a big jump in the measuring needle, this suggests that an approaching weather system is moving quickly or becoming more intense. In this case, isobars are moving quickly across your area and are possibly getting closer together. This usually results in strong winds, and can be taken as a **STRONG WIND WARNING**. However, sometimes the isobars in your area may not change position much, even though they are close together, in which case you may have strong winds and only small pressure changes.

**Setting a barometer**
The main use for a barometer is not so much to read pressure, but to measure CHANGES in pressure over time. Pressure change is usually measured by two needles rather than one. The needle connected to the insides of the barometer is called the *measuring hand.* Most aneroid barometers come with a second needle, or movable pointer, called the *setting hand*, which is free to be moved around by means of twirling a knob at the centre of the glass. When you arrange it so the setting hand is directly over the measuring hand, you have ***set your barometer.*** The idea is that you set your barometer at a certain time of the day. Then, later, **you need only glance at your barometer** to see how the measuring hand has moved. If it has moved to the left (of the setting hand), then pressures are falling (or, as some say, "the glass is falling"). If there is a steady change, then, by noting the amount of pressure change over time, you can work out the rate of pressure change.

**When to read (Diurnal Change)**
Beware of the normal twice-daily ups and downs of air pressure. Pressure rises between about 5 to 9 standard clock time and falls between 11 and 3 standard clock time. This is due to a solar-induced atmospheric tide, and is called the **"diurnal pressure change"**. The amount of this diurnal change is more in the tropics (about 3 hPa per tide) than over New Zealand (about 1 hPa).




The easiest way to remove diurnal change from your calculations is to read your barometer at the SAME TIME of the day, preferably at about 10 or 4 (am or pm), thus observing pressure change over 24-hour periods. Remember to log the pressure and its

(24 hour) change, and also (if you can) log the wind speed and direction.

**Get it adjusted**

Before you leave on a long voyage, remember to *adjust* your barometer so that it reads correct MSL pressure. Then you can use its readings to check out weather maps whilst at sea.

Adjusting your barometer is easy. All you have to do, once you position your barometer in a new location, is find out what the latest MSL pressure is (call anyone nearby with an adjusted barometer for a reading) and adjust your barometer to read this value. Official barometric readings are usually published with the weather in the newspaper. There is normally an adjustment screw found at the back of the barometer. Try to do these adjustments at a time when the pressure is not changing much and is neither very high nor very low (say about 10am or 4pm, with no fronts coming).

You also need to do this adjustment whenever you change the height location of the barometer by more than about 5 metres (15 feet), equivalent to a pressure change of half a hectoPascal.

**How to redraw a weather map**

With a PROG map, note its valid time, and as this approaches compare the map pressure at your location with your barometer reading. Any difference of more than 3 hPa suggests that the forecast map is straying away from reality. Normally, the main error is timing, and, with your barometer reading, you can redraw the PROG map and fine tune it's timing.

**Your barometer as an alarm clock**

The SEQUENCE of events shown on a weather map is usually OK even when the timing isn't. From the weather map, decide on a target pressure associated with an event you are interested in (such as the passage of a front). Mark this target pressure on the face of your barometer, and then you can monitor the closeness of this event at a glance.

It needs to be mentioned though that this is only a rough alarm clock and can easily be three hours out. The isobars on a weather map are just smoothed-out estimates and should not be taken to be exact. Your barometer may not be a useful alarm clock for a trip around the harbour, but will work well enough when planning tactics for ocean voyages.

**Weather foretelling**

A good rule of thumb in the trade wind belt is: **Do NOT continue to head south with falling pressure.**

**For the Southern Hemisphere mid-latitudes:**

The barometric readings you have logged may be turned into weather forecasts. Augie Auer, retired Chief Meteorologist for METSERVICE, has come up with the following scheme, which applies to the transient troughs found in the mid-latitudes of the Southern Hemisphere. These are rules-of-thumb based on observed weather patterns ... some have not yet been fully tested. Because of the modifying effects of land on the wind, these predictions are most accurate over sea. They should be reasonably OK for the west coast and northern part of New Zealand, and least reliable for eastern or central New Zealand. These forecasts should be used as guidance only, and will NOT be as accurate as the latest available weather forecast.

**Only use in mid-latitudes of the Southern Hemisphere**

## RISING PRESSURE

| Barometer | Wind | Weather forecast |
|---|---|---|
| | | |
| More than 1015 | S, SW | Continued fair for 24 hours<br>Slightly cooler |
| | W, NW | Continued fair for 12 hours |
| | N, NE | Fair weather |
| | E, SE | Rain/showers at first, diminishing over next 18 hours<br>Cooler; winds decreasing |
| | | |
| 1010–1015<br>(rapid rise) | SW, W, NW | Fair, followed by rain within 48 hours |
| (normal rise) | SW | Fair for 48 hours, cooler by 3–5° C |
| (normal rise) | W, NW | Fair for 48 hours, cooler by 2–4° C |
| (slow rise) | NW, N | Clearing within a few hours,<br>then fair for days |
| (normal rise) | N, NE | Fair |
| | E, SE | Clear(ing) and cooler |
| | S | Rain likely for 6–12 hours,<br>then clear(ing) and cooler |
| | | |
| Less than 1000 | S, SW | Clearing within a few hours<br>Cooler by 3–6° C |
| | W, NW | Clearing within 6 hours |
| | N, NE | Clearing |
| | E, SE | Clearing and cooler |
| | | |

**Only use in mid-latitudes of the Southern Hemisphere**

## STEADY PRESSURE

| Barometer | Wind | Weather forecast |
|---|---|---|
| | | |
| More than 1015 | S, SW | Continued fair for 48 hours |
| | W, NW | Continued fair for 12 hours |
| | N, NE | Rain within 24–48 hours |
| | E, SE | Continued fair, cooler |
| | | |
| 1010–1015 | SW, W, NW | Fair for 1–2 days |
| | N | Rain within 18–24 hours |
| | | |
| 1000–1010 | SW | Continued (rainy) conditions |
| | W, NW | Fair for 12 hours |
| | N | Rain within 12–18 hours |
| | | |
| 1000–1015 | NE | Rain within 12–18 hours<br>Foggy in spring/early summer |
| | E, SE, S | No change next 6–12 hours<br>If a front has just passed,<br>rain/gales for 6–12 hours |
| | | |
| Less than 1000 | S, SW | Continued (threatening?) weather<br>Cooler by 3–5° C |
| | W, NW | Continued (stormy) weather |
| | N, NE | Front coming with rain and a south to south-west wind change within six hours |
| | E, SE | No change until pressure rises or falls |
| | | |

**Only use in mid-latitudes of the Southern Hemisphere**

## FALLING PRESSURE

| Barometer | Wind | Weather forecast |
|---|---|---|
| | | |
| More than 1015 | SW, W | Continued fair for 24 hours<br>Slowly rising temperatures by 1–3° C |
| | NW | Fair for 6–12 hours<br>Rising temperatures by 2–4° C |
| | N, NE | Rain within 18–24 hours, wind increasing, temperatures rise by 1–3° C |
| | SE, S | Rain within 24–48 hours |
| | | |
| 1010–1015<br>(slow fall) | N, NE | Rain within 12–18 hours (or more rain)<br>Wind gradually increasing<br>Perhaps foggy |
| (rapid fall) | N, NE | Strengthening winds<br>Rain in 9–15 hours, or continued rain |
| (slow fall) | E | In summer, light winds,<br>possibly DRY for several days<br>In winter, rain within 24 hours |
| (rapid fall) | E | In summer, rain probable<br>within 12–24 hours<br>In winter, rain or snow<br>Wind swinging south-easterly and rising |
| (slow fall) | SE | Rain within 12–18 hours,<br>or continued rainy<br>Wind might increase |
| (rapid fall) | SE | Rain within 9–15 hours<br>Wind increasing<br>Followed within 36 hours by clearing conditions, then frosty if winter |

**Only use in mid-latitudes of the Southern Hemisphere**

## FALLING PRESSURE (cont.)

| Barometer | Wind | Weather forecast |
|---|---|---|
| | | |
| 1000–1010 | SW | Fair for 12–24 hours |
| | W | Continued fair for 12–15 hours,<br>then possible southerly |
| | NW | Fair for 18–24 hours, front coming? |
| | N, NE | Rain within 6–12 hours |
| | E | Wind increasing,<br>rising minimum temperatures by 3–5° C |
| | SE, S | Rain within 12 hours, but if front has just passed (and pressure is still falling) then rain and gales next 6–12 hours (in comma head) |
| | | |
| Less than 1000 | SW, W | Fair for 6–9 hours with dry air,<br>then possible southerly |
| | NW, N | Rain within six hours<br>Winds reaching gale<br>Minimum temps rising by 1–2° C |
| | NE, E | Rain within six hours |
| | SE, S | Rain, or rain imminent (snow in winter) |
| | | |

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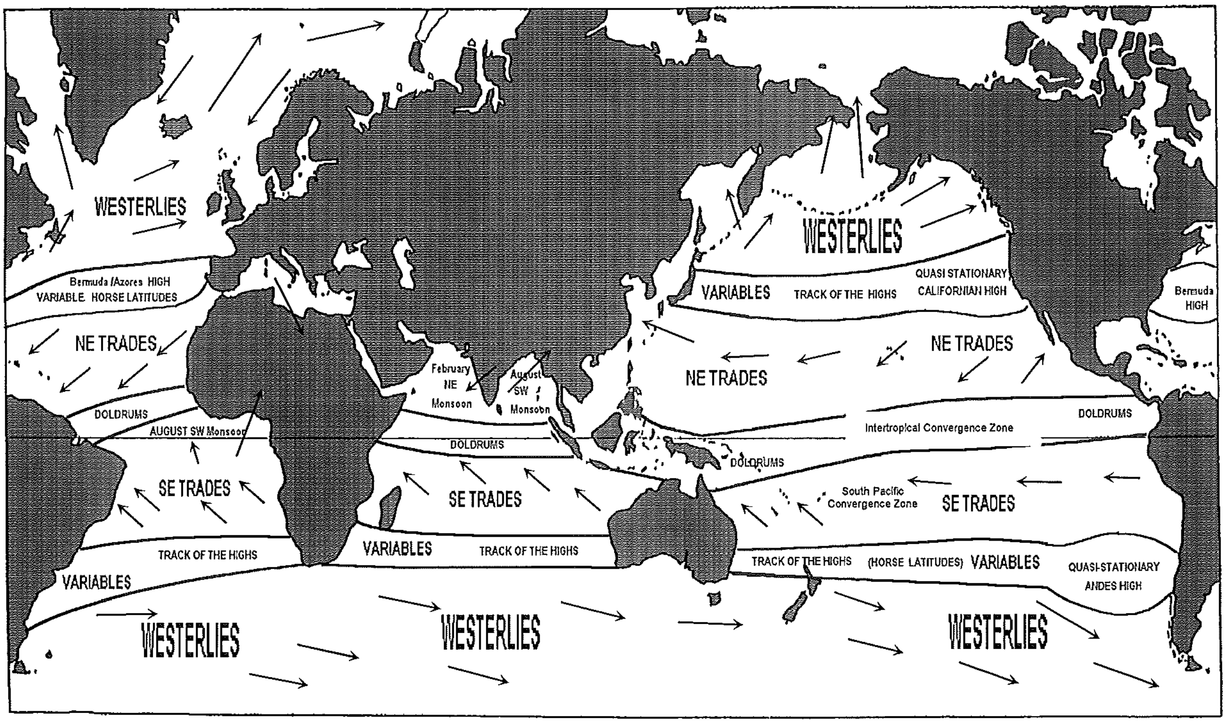
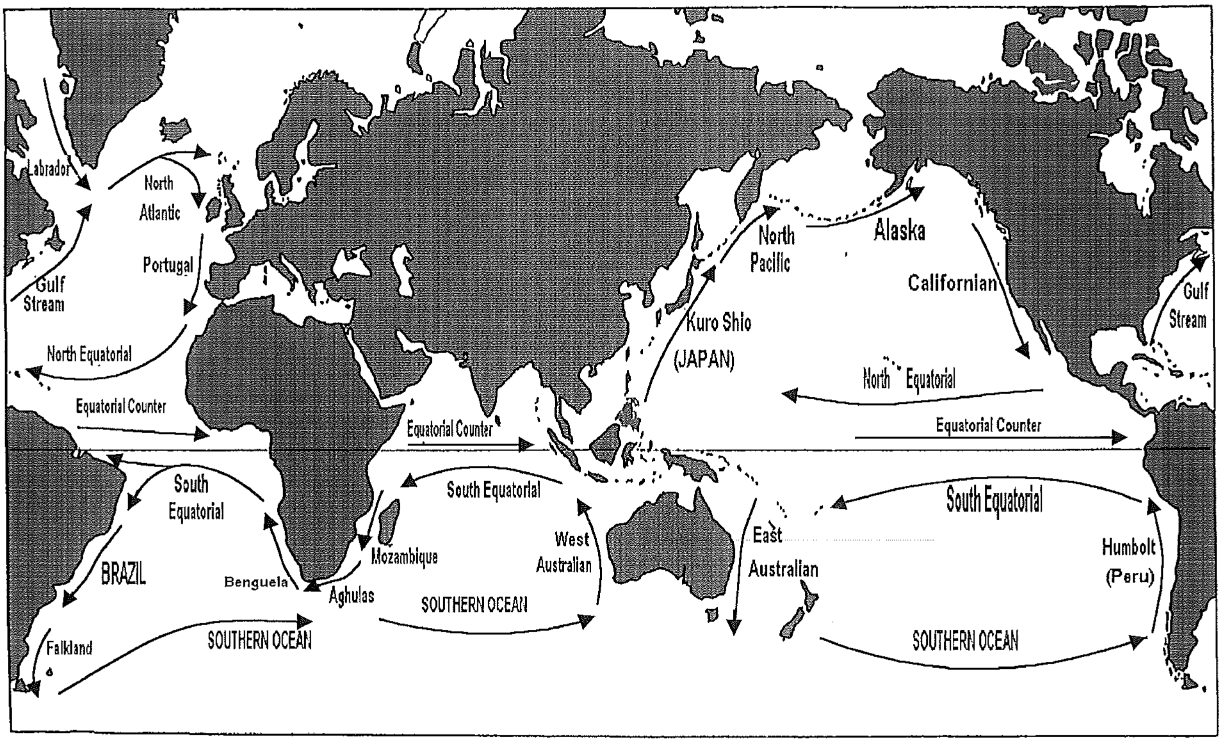
## Basics of World Weather

Listed here for reference are maps of the world's basic wind and sea currents as found in the various oceans, plus a map of oceanic bad weather.

### WORLD SURFACE WINDS




### WORLD OCEAN CURRENTS



## WORLD OCEANS — BAD WEATHER AREAS