How does the wind blow?

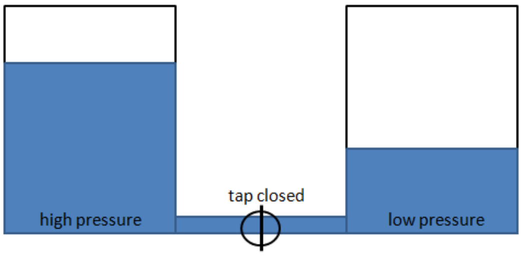
Oh wind, why do you never rest?
Wandering, whistling to and fro,
Bringing rain out of the west,
From the dim north bringing snow?
Christina Rossetti

Why do we have wind? The simple answer is that the air is always moving from areas of high pressure, where there is more atmosphere above us, to areas of low pressure, where there is less. Air pressure is literally a measure of the weight of the air above you.

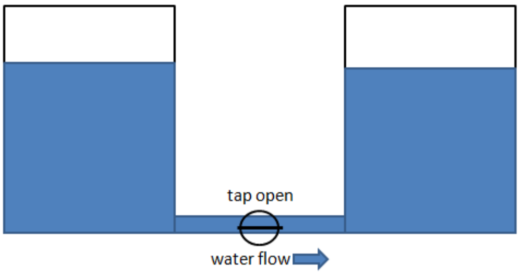
Astronauts aboard the International Space Station captured this photograph on July 31, 2011. Closest to Earth's surface, the orange-red glow reveals the troposphere—the lowest, densest layer of atmosphere, and the one which contains our weather. A brown transitional layer marks the upper edge of the troposphere, known as the tropopause. The stratosphere is a milky white and grey layer above that. The upper reaches of the atmosphere fade from shades of blue to the blackness of space. Image courtesy of NASA's Earth Observatory.

90% of the mass of the atmosphere is contained in the troposphere, the approximately 10km thick layer of the atmosphere closest to the ground and which contains our weather – clouds, rain, wind, snow and everything else. The thickness of the troposphere varies from place to place and time to time, depending mainly on the fact that some bits of the Earth are being heated more than others by the Sun, and on the whole three dimensional movement of the atmosphere.

Think about having two containers with a pipe and tap joining them at the bottom, and a higher water level in one than in the other. Where the water level is higher, the weight of water in that container is higher and the pressure at the bottom of the container is higher. In the same way, where there is more atmosphere above us, the pressure at the ground is higher:



If you open the tap between the two, you intuitively know that the water will flow from the bucket with the higher water level to the other bucket until the water level has equalised:



It is exactly the same in the atmosphere – air is always trying to flow to make the pressure the same everywhere.

Unfortunately it's not quite that simple, winds do not blow straight from high to low pressure – other things also have an effect. Think about the way the Earth rotates once around its axis every day. If you are standing on the Equator, you travel a distance of 40,000km eastwards every day – an approximate speed of 1600km/hr. You don't notice that you are travelling that fast, because the air around you is travelling at the same speed, so there is no wind. On the other hand, if you are standing on one of the poles, all you would have to do in 24 hours is turn once on the spot. But what happens if air at the Equator starts moving towards the north pole? It keeps moving eastward at the same speed that it had at the Equator, but as it moves poleward, the ground below it is moving ever slower – so the wind effectively overtakes the ground below. If it started at one longitude, it'll end up East of that longitude as it moves polewards, so it appears to veer off to the right in the Northern Hemisphere. Conversely, air moving from the north pole towards the equator ends up being left behind by the ground it's travelling over, and ends up west of the longitude it started at. This is known as the Coriolis Effect. On the very large scale, it gives us the Trade winds and the mid-latitude westerlies. There is a lovely demonstration of this at http://www.metlink.org/wp-content/uploads/2013/11/media/video/coriolis.mov

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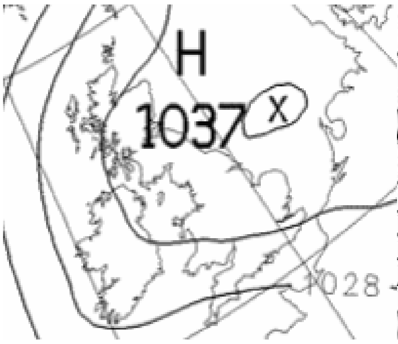
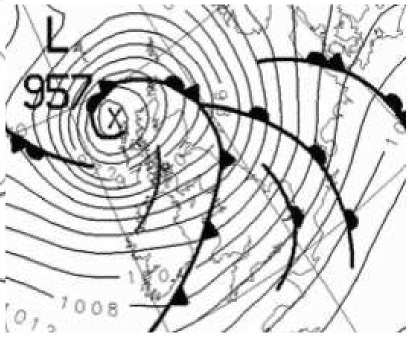
If you go to the Met Office website www.metoffice.gov.uk/weather and look at the UK forecast, you can switch between looking at pressure and looking at wind. In general, as a result of the combination of the pressure gradient and the Coriolis Effect, the wind always blows along pressure contours (isobars). If you stand with your back to the wind in the Northern Hemisphere, air pressure will be lower on your left. This is another way of saying that, in the Northern Hemisphere, the wind blows in an anticlockwise direction around a low pressure area, and in a clockwise direction around a high pressure system. Also, the closer the isobars are to each other, the bigger the difference in pressure and the faster the winds blow.





On the left hand picture, the pressure contours are relatively widely spaced. Weak winds will be blowing along the contours in a clockwise direction, giving southerly winds across Ireland. On the right hand picture, the pressure contours are much closer together, giving much faster wind speeds. The winds will be blowing around the contours in an anticlockwise direction, giving westerlies across most of the UK.

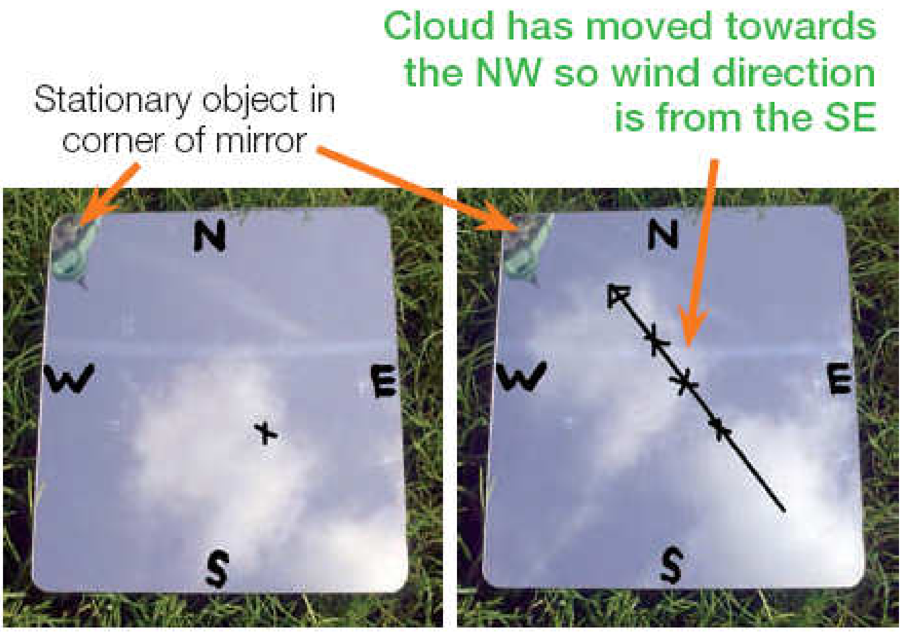
Another force affecting the way that winds blow at the Earth's surface is friction. The rougher the surface of the ground or water, the more the wind blowing close to the ground is slowed down.

Our weather in the UK is largely dependent on which way the wind is blowing. If it's coming from the North, it'll be colder than if it's coming from the South. If it's blown over a lot of ocean before it gets to us, then we're going to get wetter than if it's reached us over land.

Year 3 pupils at Greave Primary School investigating the effect of friction on wind speed. The further away from the ground you hold the anemometer, the faster the wind speed. This is best done on a windy day. If you don't have access to three anemometers, you can make anemometers or wind meters to measure wind speed (instructions at www.rmets.org/experiments).

How can you measure which way the wind is blowing? You could make a wind vane, a wind sock or even just blow some bubbles and see which direction they head off in – the wind direction will be the opposite to this as it is defined as the direction the wind is coming from . Think of a north wind – it is cold because it has blown *from* the north. But how do you know whether the wind is blowing the same way higher in the atmosphere? This is where a nephoscope is useful - you'll need a mirror, a compass, a marker pen and a day when there just a few clouds in the sky.

- Mark the four main compass directions on your mirror with a pen.
- Find an outdoor location where you can see the sky clearly and where you can sit still for up to five minutes.
- Place the mirror and the compass flat on the ground. Position the compass so that it is pointing north. Twist the mirror so that the 'N' on the mirror is lined up with north on the compass. Sit down so you can see a cloud in the mirror. It doesn't matter where you sit around the mirror.
- If you can see a stationary object (maybe the edge of a building or tree) mark it on your mirror too so that you can check that you're not moving your head around too much.
- Find an easily recognisable part of a cloud and mark this on the mirror.
- Follow this cloud feature very carefully and repeatedly mark it on the mirror until you have drawn a track. The track should roughly form a straight line.
- The direction the line came from is the wind direction at the height of the cloud. If you want, you can use the cloud guide at http://www.opalexplorenature.org/sites/default/files/7/file/Cloud-chart.pdf to see what type of cloud it is, and hence what its rough height might be.

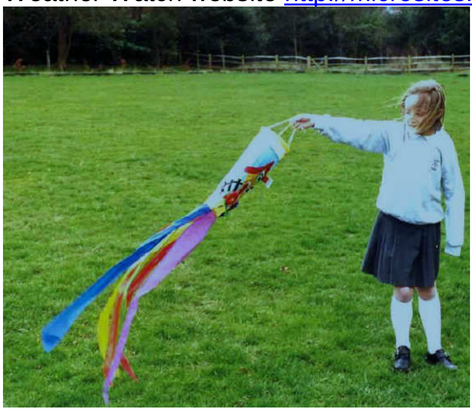


Even without an anemometer, you can estimate wind strength using the Beaufort Scale. For reference, the highest wind speed ever recorded in a tornado was 300miles/ hour, the highest wind speed ever recorded in a hurricane was 190 miles/ hour (although it is very difficult to accurately measure the wind speed in either, as instruments tend to get broken!) and in December 2011, a UK record breaking gust of 164 miles/ hour was recorded on the top of Cairngorm. In comparison, Formula 1 cars typically get up to 185 miles/ hour.

Wind Force	Description	Speed		Specifications
		kph	knots	
0	Calm	0	0	Smoke rises vertically
1	Light Air	1-5	1-3	Direction shown by smoke drift but not by wind vanes
2	Light Breeze	6-11	4-6	Wind felt on face; leaves rustle; wind vane moved by wind
3	Gentle Breeze	12-19	7-10	Leaves and small twigs in constant motion; light flags extended
4	Moderate Breeze	20-28	11-16	Raises dust and loose paper; small branches moved.
5	Fresh Breeze	29-38	17-21	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	Strong Breeze	38-49	22-27	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
7	Near Gale	50-61	28-33	Whole trees in motion; inconvenience felt when walking against the wind.
8	Gale	62-74	34-40	Twigs break off trees; generally impedes progress.
9	Strong Gale	75-88	41-47	Slight structural damage (chimney pots and slates removed).
10	Storm	89-102	48-55	Seldom experienced inland; trees uprooted; considerable structural damage
11	Violent Storm	103-117	56-63	Very rarely experienced; accompanied by widespread damage.
12	Hurricane	118 plus	64 plus	Devastation

The Beaufort Scale

There are lots of other aspects of the wind which can be explored with primary children – for example; how can the wind be represented in art, poetry and music; can you make musical instruments which sound like the wind?
There is a weather sounds activity for Early Years on the BBC school radio website at http://www.bbc.co.uk/schoolradio/subjects/earlylearning/stimulussounds/programmes/weather, and there are some other lovely weather music and art ideas on the South East Grid for Learning Weather Watch website http://microsites.segfl.org.uk/view_project.php?id=39 .

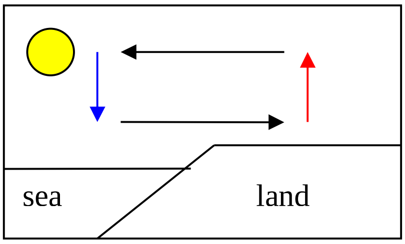


Unusual Winds

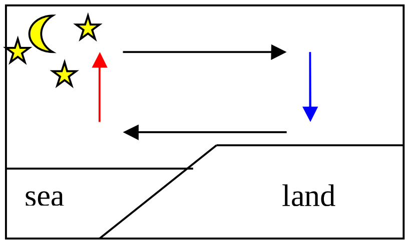
People around the world have given their local winds some wonderful names!

Helm wind: a strong, blustery easterly wind found in the Cross Fell area of Cumbria
Moazagoatl: Found in southeastern Germany, it is found downwind of mountains, just like the Helm wind.
Chinook: This is the same sort of wind again, but found in North America, where the Great Plains meet the Canadian prairies.
Gibli: is a hot, dry, south to southeasterly dust-bearing desert wind, found in Libya, usually in spring and early summer
Simoom: A very hot, dry, suffocating and dust-laden wind that blasts across the Sahara and Arabian deserts.
Williwaw: a sudden violent, cold, gust of wind descending from the mountains to the sea in the Straits of Magellan or the Aleutian Islands.

Case Study: Sea Breezes
On sunny days, land heats up quicker than water. As the land warms, the air above it becomes warmer too, and starts to rise, which in turn means that the air pressure above the land starts to fall. Over the sea, the air is relatively cool and sinks, meaning that the air pressure is relatively high. A wind starts to blow from the high to the low pressure – a sea breeze.
At night the opposite happens – the land cools down more quickly than the water and you are left with higher pressure over the land. A wind starts to blow from the land to the sea – a land breeze



Sea Breeze



Land Breeze

Other recommended resources:

http://www.tes.co.uk/teaching-resource/An-introduction-to-wind-6185614/

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