The weather and climate of Antarctica

Of all the continents Antarctica is the coldest, the windiest and the driest - the following helps to explain why these are so.

1. Why the coldest

Radiation

Of the three ways heat energy is transferred (radiation, convection, conduction) it is radiation which is most important in Antarctica. This is because the hotter an object the shorter the wavelength it emits, for example

Short wave radiation.	Long wave radiation
The Sun emits a wide range of radiation and is hot enough (over 5700°C) to emit short wave 'ultraviolet' radiation. It is 'UV' that can cause damage to cells.	The Earth averages 16°C and emits much longer 'infrared' radiation Such radiation can only be detected using night vision or thermal imaging cameras.

When shortwave radiation is absorbed by a surface it increases the temperature of the object. As the object continues to warm it will then emit long wave radiation into the atmosphere. The atmosphere, particularly when cloudy, absorbs and then emits long wave radiation back to earth, something which plays a crucial role in determining the temperature of the atmosphere near Earth's surface.

This is known as the **'greenhouse effect'** and without it Earth would be an ice planet, being an average of 30°C cooler

Although heating occurs all over Earth the position of the sun significantly affects on how much heating occurs. For example at the South Pole, even in mid summer the sun is never more than 23 degrees above the horizon, and 'feels cold' because:

- much of its short wave radiation is absorbed during its long, low journey through Earths atmosphere, so there is little left by the time it arrives at the surface.
- the quantity of energy striking 1 m2 at the equator is spread over twice the area at the pole.
- the whiteness of Antarctica means that any energy that does reach the surface is likely to be reflected away again, rather than be absorbed. The measure of how much radiation is reflected from a surface is known as 'Albedo' and is often shown as a percentage.

Finally, although these factors work together to keep both poles cold, Antarctica remains colder than the Arctic because it is surrounded by the Southern Ocean (rather than continents) whose relentless circulation around Antarctica acts as a barrier to warmer water and air moving southwards.

Midnight. A low sun is one reason Antarctica is so cold.

2. Why the windiest

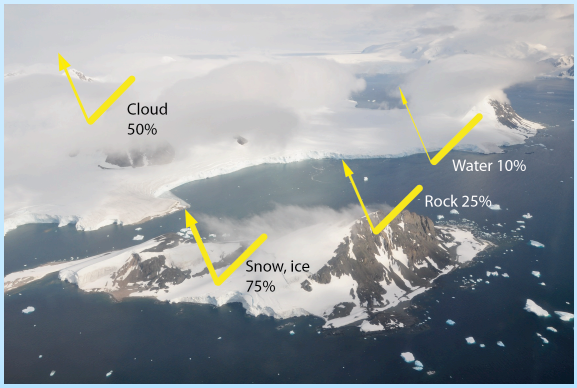
Wind is air moving from a place of high pressure to a place of lower pressure, with greater differences causing stronger winds. What causes a pressure difference is often a temperature difference, with ANY temperature difference being sufficient. This means winds blow just as easily between warm and hot places in Australia, as they do between freezing and chilly places in Antarctica.

Katabatic winds

Katabatic winds are caused by gravity pulling cold, heavy (dense) air downwards. Such winds are a special feature of Antarctica because of its high polar plateau from which the air can descend (whereas the Arctic is mainly flat, sea ice). Beyond the coast, and blowing across flatter surfaces, katabatic winds rapidly loose their strength

As Katabatic winds race towards the coast they are channelled through valleys between the mountains reaching 200kph and blowing unrelentingly for days at a time, making working on the valley floor noisy and difficult. However a few hundred metres above the valley floor it can be calm and silent - unless you descend into the katabatic wind, which can be so sudden that boots disappear amongst drifting snow, while hair remains unruffled.

Although katabatic winds are a feature of Antarctica their influence is worldwide, as the air from the polar plateau is be replaced from high above, which in turn comes from the tropics. In this way Antarctica's katabatic winds affect the flow of air worldwide.



Antarctic albedo. The percentage shows how much visible light is reflected from each surface, and therefore shows how much is absorbed.

3. Why the driest

Being the coldest continent, helps to make Antarctica the driest, simply because the colder the air the less moisture it can hold. This also explains why large snowfalls usually occur near the coast, where warmer air moves over open water, and is able to pick up sufficient moisture. In Antarctica this link between snowfall and open water is so strong that inland, even when the sea cannot be seen, a heavy snowfall is a good indication that the continuous cover of sea ice has broken apart.

Sublimation

Sublimation is a change in state, from a solid to a gas (vapour) without passing through a liquid state. This is commonly shown using solid carbon dioxide which vanishes to carbon dioxide gas, without getting wet (hence its name 'dry ice').

In a similar way molecules of water continuously leave solid ice and become water vapour in the air. In cold, dry conditions centimetres of solid ice can be lost to the air in this way, especially when it is windy. The result is that over a few days tent pegs, markers and rocks may appear to rise out of ice and within a few hours a line of solidly frozen washing is soft and dry.

The drying effect of sublimation is such a major challenge for organisms that some Antarctic habitats, such as the McMurdo Dry Valleys, are some of the most challenging on earth.

Snowfall per year (shown as equivalent rainfall)	
East Antarctic plateau	< 50 mm
East Antarctica coast	> 500 mm
West Antarctica	> 1000 mm
McMurdo Dry Valleys	< 0 mm, due to sublimation

Autumn is the coldest season in Antarctica, and is possibly a reason why Scott's polar party.all died on their return journey.

Practical activity: Shadow Ratios

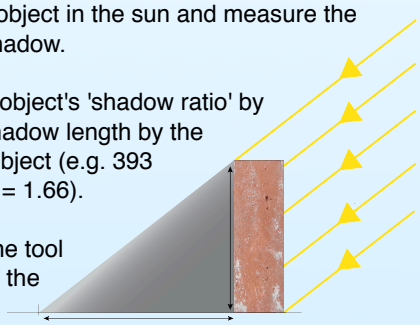
Introduction

A 'shadow ratio' is simply the ratio between an objects height and the length of its shadow. The lower the sun is in the sky, the greater the shadow ratio.

What to do

1. Place a solid object in the sun and measure the length of its shadow.

2. Calculate the object's 'shadow ratio' by dividing the shadow length by the height of the object (e.g. 393 mm / 230 mm = 1.66).



3. Using an online tool or an app' find the shadow ratio for places further south and/or north at the same day. (e.g. *The Photographer's Ephemeris, Sun Seeker* app').

4. Option: Record the shadow ratio's at an Antarctic Base at the two equinox's, plus winter and summer solstices.

How it works

The height of the sun above the horizon (elevation) depends on:

- the time of day
- the time of year
- the latitude

The use of a 'shadow ratio' means the height of an object becomes irrelevant.

Relevance

- Less energy is absorbed when the sun is lower in the sky (due to increased absorption during the longer path through the atmosphere, and increased reflection from surfaces)
- At both poles the shadow ratios are especially high, even in summer.
- These act to keep the poles cold.

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Science Curriculum: Nature of Science, Physical World, Planet Earth & Beyond Levels 2 - 5.
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