Weather systems

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http://www.metlink.org/weather-climate-resources-teachers/weather-systems-video.html

What are we talking about?

A bit of history

- The first scientific study and classification of these weather systems was performed by a group of Norwegian meteorologists – the Bergen School
- The location was no coincidence – Bergen experiences a lot of weather systems
- Working without the benefit of satellite pictures, this group did a remarkable job of describing the nature of weather systems

A bit of history

This figure from a 1922 paper by Bjerknes and Solberg shows pictures of a typical mid-latitude depression that will be familiar to anyone who has read a modern textbook on weather systems

Why do they occur?

- Depressions occur as a consequence of the pole-to-equator temperature gradient
- The equator is always warmer than the poles, especially in the winter hemisphere
- The atmosphere acts to prevent the equator continually heating up and the poles continually cooling down
- Mid-latitude depressions play a vital role in this process

A pole-to-equator temperature gradient

The south to north rate of change of temperature is greatest between 30 and 70 degrees north
Back to the history books

- The Bergen meteorologists realised that this temperature gradient was a key part of the formation of weather systems.
- They referred to the temperature gradient as “the polar front” – a boundary separating warm tropical air from colder air near the pole.
- They believed that all depressions formed on this polar front.

Pole-to-equator temperature gradient

- This large temperature gradient is unstable.
- This means that if a small perturbation is introduced to the gradient, it will grow with time.

Waves on the polar front

- A small perturbation on the polar front can grow, a bit like an ocean wave approaching the shore.

Such systems are often called “wave depressions” by meteorologists.
Waves on the polar front

Eventually the wave “breaks”, stranding warm air on the cold side of the front, and cold air on the warm side.

A sequence of wave depressions

This sequence shows the “classical” lifecycle of a depression. The grey shading shows the region of continuous cloud cover. The warm front (red) and cold front (blue) denote the boundaries of the “wave” of warm air – often called the warm sector. But what about the purple line?

A more detailed look...

The wave on the polar front model is a useful concept when understanding the role of depressions in moving warm air polewards. However, it doesn’t describe the detailed structure of depressions such as the winds, cloud and rain associated with them.
At this point it’s important to remember that weather systems are **3 dimensional**.

In fact the 3rd dimension is crucial – all the cloud and rain produced by a depression is caused by **air rising and cooling**.

At this stage we’ll look at the vertical structure of a developing depression.
Why does the pressure fall in the middle of a depression?

- This is perhaps the most obvious question to ask about depressions.
- In order to answer it we must again think about the 3-D structure of the system, and vertical motion.
- We also need to consider what atmospheric pressure actually is.

Atmospheric pressure

- Near the centre of a depression, air is rising.
- The tropopause acts as a lid to vertical motion, so the air spreads out horizontally at this level: divergence.
- Near the surface, air converges into the column to replace the air being lost through rising motion.

Atmospheric pressure and winds

- The stronger the pressure gradient in a depression, the stronger the winds around it.
- The Earth’s rotation means that winds don’t blow directly into the centre of the low but instead blow around the low – in an anticlockwise direction in the northern hemisphere.
- The absolute value of pressure in the centre of the depression is less important than the difference in pressure between the centre and the edge of the system.
Atmospheric pressure and winds

Surface pressure chart, 0000, 24th Jan, 2009.
The depression in the Bay of Biscay has winds of hurricane force on its western and southern flanks.

Airflow through depressions

• The “classical” model of a depression, with its fronts and warm sector doesn’t really describe the flow of air through the system.
• Without a constant input of warm moist air, a depression would soon lose energy and start to dissipate.
• This feed of warm moist air is provided by an airflow called the Warm Conveyor Belt.
Pole-to-equator temperature gradient

- On the 23rd of January, there was a strong temperature gradient across the Atlantic.
Rainfall Radar

Bright colours show heaviest rain

1900: 23/1/09
0600: 24/1/09
0600: 24/1/09

Why was this depression so intense?

- The very strong temperature gradient across the Atlantic
- Very strong upper level winds in excess of 200mph at heights of about 9km
- The storm formed further south than most depressions so the air feeding into the system was very warm and moist