Storm Chasers – how heat and convection help to form storm clouds

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This resource was developed as a result of participation in CSIRO's teacher professional learning program, Educator on Board.

Storm Chasers – How Heat and Convection Help to Form Storm Clouds

Activity 1 - Student Activity "**What is temperature**?" Suggested activity duration 10 minutes

Step 1. Watch the video: "Curiosity starter – What is temperature". (1 min)
https://www.youtube.com/watch?v=_4BX_W8h7fs

Step 2. Ask the students to estimate the temperature of various objects in the classroom. Eg the air, desk top, metal legs on the desk, metal in the sink, carpet, walls and write their estimate down in their books.

Step 3. The teacher or selected students can measure the actual temperature using a digital probe thermometer or a digital infrared thermometer.

Step 4. As a class (or in small groups) – discuss reasons for why the temperature of some objects "feel" different to others.

Step 5. Students to write a definition of "Temperature" and why some objects may feel colder than other objects.

For the teacher

- Objects in the room will all be approximately the same temperature, but they will "feel" different. Metal objects will "feel" colder than most non metal objects even though they are the same temperature.

- Temperature is a physical property related to the average kinetic energy of the atoms or molecules of a substance.

- Metal is a better conductor of heat than other materials. The metal will "feel" colder than the ambient room temperature because it conducts heat away from your hand which is at 37 degrees Celsius.

Reference for activity 1:

Science as a Human Endeavour. (2020, Jun 2). *What is Temperature?* [Video].
https://www.youtube.com/watch?v=_4BX_W8h7fs

Activity 2 - Teacher Demonstration "Boiling water without adding extra heat"

This demonstration "boils" water at lower temperature by lowering the air pressure.
This is a good "wow" demonstration.

Step 1. Watch the video: "Curiosity starter – Can you boil water without heating it". (1 min)
https://www.youtube.com/watch?v=fP812b17gBc

Step 2. Ask the students if they know the temperature at which water boils. Most will say 100 degrees.

Step 3. Draw up some warm water (40 degrees Celsius) into a 50ml or 100ml needleless syringe.

Image credit: D Dieckfoss 2020

Step 4. Place your finger over the inlet and draw the plunger out to reduce the air pressure. The water will form bubbles and start to boil. Water boils at lower temperatures with lower pressure.

Step 5. Further discussion. When water boils it changes state from liquid to a vapour. Why does water evaporate from puddles, off the road or path when it doesn't reach 100 degrees?

For the Teacher

- Temperature is a physical property related to the **average kinetic energy** of the atoms or molecules of a substance. The average temperature of a puddle of water may be only 10 or 15 degrees but molecules at the surface will have a far greater kinetic energy due to absorbing more of the Sun's energy. These molecules become vapour and "evaporate".

- At standard atmospheric pressure (1 atmosphere = 0.101325 MPa), water boils at approximately 100 degrees. Air pressure varies constantly and on top of mountains it is considerably less than at sea level. On top of Mt Everest water boils at approximately 70 degrees Celsius.

- Heat causes some of the liquid water – from places like oceans, rivers and swimming pools – to change into an invisible gas called water vapor. This process is called evaporation and it's the start of how clouds are formed.

- Clouds are created when water vapor, an invisible gas, turns into liquid water droplets. These water droplets form on tiny particles, like dust, that are floating in the air.

Reference for Activity 2:

Science as a Human Endeavour. (2020, Jun 2). Can you boil water without heating it". (1 min)
https://www.youtube.com/watch?v=fP812b17gBc

Activity 3 – Student Activity "Swirly colours by convection". Heat transfer by convection.

*Suggested activity duration: 10 to 15 minutes.

* Teacher supervision is required. Please ensure that you have assessed this activity for risk and that any potential risks are mitigated with appropriate strategies outlined in a plan. All students should have prior experience with the safe practice of lighting a Bunsen burner.

Aim – To investigate heat transfer by convection.

Method –

Step 1. Pour 200ml of water into a 250ml beaker.

Step 2. Place the beaker on a tripod with a gauze mat over a Bunsen burner or on a hot plate.

Step 3. Carefully place a drop of food colouring into the beaker via a straw or dropping pipette so that the food colouring touches the bottom of the beaker. Be careful not to stir the water.

Step 4. Light the Bunsen burner and position it underneath the beaker. As the water is heated, the process of convection can be observed.

- **Note** The water will only need to be heated for a short period of time and should not be heated to boiling point.

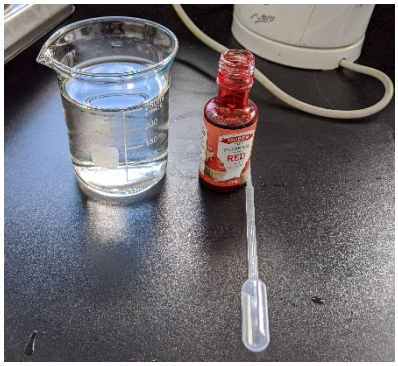

Image credit: D Dieckfoss 2020

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For the Teacher

- Convection transfers heat from one place to another by the motion of a fluids or gases. Convection is different from conduction, which is a transfer of heat between substances in direct contact with each other.

- Convection currents form because a heated fluid or gas expands, becoming less dense causing it to rise away from the heat source. As it rises, it pulls cooler fluid down to replace it. This fluid in turn is heated, rises and pulls down more cool fluid. This cycle establishes a circular current that stops only when heat is evenly distributed throughout the fluid.

Activity 4 – Teacher Demonstration "Cloud in a jar".

Step 1. Obtain a large jar or measuring cylinder

Step 2. Boil some water in a jug.

Step 3. Pour a small amount of the boiling water into the measuring cylinder and cover top with a watch glass with ice.

Step 4. A match can be lit, blown out and dropped in the beaker to provide a little smoke aiding the formation of the cloud.

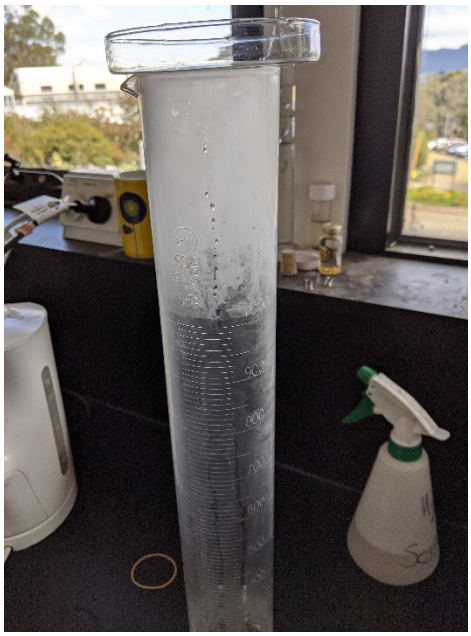


Image credit: D Dieckfoss 2020

For the Teacher

- Some of the hot water changes into invisible water vapor. This layer is just above the water and looks clear.

- Clouds are created when water vapor cools and turns into tiny liquid water droplets near the top of the measuring cylinder. These water droplets form on tiny particles, like dust, that are floating in the air.

Activity 5 – Student Activity "Storm Chasing Science"

Science as a human Endeavour

Step1. Download and view the "Stormchaser" profiles document.

https://drive.google.com/drive/folders/18e0equLMa7XVDWX8rVHWvUBacLRFOlEa?usp=sharing

Step 2. Watch the Stormchaser video. (2 min)

https://www.youtube.com/watch?v=dOI1Mah9YrE&list=PLaqmyvBWI1xfFRAD-93JNnLBj8am3kGGh&index=3

Investigating the RV Investigator's Investigators.
"Science as a Human Endeavour"

The RV *Investigator* is Australia's 94-metre ocean research vessel that is responsible for data collection within Australia's National Marine Research capabilities. Everywhere the *Investigator* goes it maps the topography of the sea floor and collects oceanographic and atmospheric data. Researchers from all over Australia and indeed the world conduct research on the ship. Each voyage has a new team of researchers and every voyage has a different focus. On the last voyage of 2019 we asked a few of them to tell us their story. There were quite a few surprises but they all had two things in common, curiosity and a desire to keep on learning.

Storm Chasers

Selfie - Alain Protat

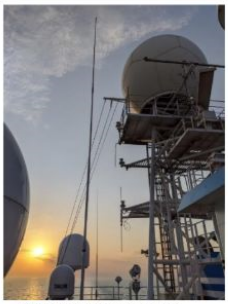
Dr. Alain Protat
Chief Thunder Radar

Occupation: Senior Principal Research Scientist
Fields: Radar meteorology
Organisation: Australian Bureau of Meteorology
Enjoys: Connecting Scientists and Listening to my kids play music

I was born in France and have a lovely wife and three kids (16, 14, and 12). I moved to Australia in 2007 to work at BOM (Bureau of Meteorology). I lead the "Radar Science and Nowcasting" Team at BOM. I use radars at different frequencies and on different platforms (ground, ship, aircraft, satellite) to better understand cloud and convection (**storm**) processes. On this voyage I am the chief scientist, which means I have the biggest cabin but also a lot

Quick Facts

- *The dual polarising radar on the Investigator is one of the most advanced available and is used to help calibrate land based radars.*
- *After all these years doing radar research, I am still passionate about my job, probably even more than before.*



Dual Polarising Radar on the Investigator. Photo D Dieckfoss

For more information;
https://www.researchgate.net/profile/Alain_Protat
https://www.youtube.com/watch?v=tLanMaOlAiA

Step 3. Discussion or assignment questions.

1. What do you think it would be like to be a "Storm Chaser"?
2. What sort of "technological advances are on the Investigator that make it a valuable tool in weather forecasting?
3. Why do you think some storms are more violent than others?
4. Write your own "Storm Chaser" profile.

References for Activity 5:

Science as a Human Endeavour : Channel https://www.youtube.com/channel/UCa7l9VWsg7jP25saQLnP14g/

Science as a Human Endeavour. (2020, Apr 15). Storm chasing on the RV Investigator – 25th December 2019. [Video]. https://www.youtube.com/watch?v=dOI1Mah9YrE

CSIRO. RV *Investigator*. Available at: https://mnf.csiro.au/en/RV-Investigator

Activity 6 – Student Activity "Putting it all together"

Ask students to write the steps involved in the formation of storm clouds.

For the teacher.

1) Temperature is a physical property related to the average kinetic energy of the atoms or molecules of a substance.

2) Heat can be transferred by conduction (Activity 1) or by convection (Activity 3)

3) Water molecules can absorb heat and change state from liquid to vapour

4) Lowering the air pressure changes the boiling point (and freezing point) of water (Activity 2)

5) Hot water and hot air rise and help the atmosphere to circulate – convection (Activity 3)

6) As moist air rises due to convection it moves up to where temperatures and pressures are lower. The moist air condenses into clouds (Activity 4)

7) Storm clouds develop where the convective process is strongest. Hot moist air moving rapidly up in top colder low pressure regions higher in the atmosphere. (Activity 5)

8) There is still much we don't know about how storms develop, and researchers continue to be curious and use ships like the RV *Investigator* to increase our understanding of weather patterns and storm development. (Activity 5)

Reference for Activity 6:

Bureau of Meteorology – What's that cloud (15 Feb 2016)

http://media.bom.gov.au/social/blog/895/whats-that-cloud/#:~:text=Cloud%20formation&text=As%20this%20moist%20air%20rises,than%20raindrops)%2C%20forming%20clouds.