Creating Science – Cyclones, Tornadoes and Vortexes

Cyclones, tornadoes, even planetary accretion discs and solar prominences – vortexes are everywhere, so what are they?! ***#CreatingScienceVortexes***

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Earth and Space sciences Y6: Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)
- Earth and Space sciences Y4: Earth's surface changes over time as a result of natural processes and human activity (ACSSU075)
- Earth and Space sciences Y1: Observable changes occur in the sky and landscape (ACSSU019)

Science inquiry skills

- Planning and conducting year 2: Participate in guided investigations to explore and answer questions (ACSIS038)

Science as a human endeavour

- Year 2: Nature and development of science, Science involves observing, asking questions about, and describing changes in, objects and events (ACSHE034)
- Use and influence of science, People use science in their daily lives, including when caring for their environment and living things (ACSHE035)

Cross curricular outcomes

- Humanities and social sciences Y7: 'Water in the World' - Causes, impacts and responses to an atmospheric or hydrological hazard (ACHGK042)

Science vocabulary

Tier 1: Cyclone, tornado, hurricane

Tier 3:

- Vortex, vortexes. A whirling mass of fluid or gas, such as a cyclone or whirlpool.
- Torus, tori. A circle or ring spinning around and through itself.

Warning

- VORTEX BOTTLES ARE HEAVY! Not too heavy, but the bigger the bottles are, the more water they can hold, the longer they will create a vortex for, and the heavier they get! Be careful!
- Water is involved, please exercise all appropriate caution.
- We may be using food dye, which can stain clothes and hands, please be careful.

Preparation

- A deep tub of water per pair of students – anywhere between 2 litres and 2.5 million litres should do (if you have the chance to grab a completely still Olympic swimming pool, more power to you!)
- one spoon per student – the rounder the better.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience.

Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity is well suited to this age group. Students at this age can have difficulty with focus. Avoid tangents if you're attempting to make a key point.

Middle:

This activity is well suited to this age group.

Teen:

Challenge older students to understand and explain the science behind what causes cyclones and tornadoes. Even if they can't get the full story, help them get what they can understand correctly.

Engage

- Allow students to play with some vortex bottles
- If possible Use a fog machine in a room with very still air, and when you run your hand through the fog or step on it, little swirling eddies are clearly visible.

Ask students what they know about willi-willies, tornadoes, and cyclones.

Explore

Allow students to experience the following:

- This swirling, twisting motion is very common in all liquids, gases, and plasmas, and it is called a VORTEX (the plural is vortexes or vortices, with subtle differences in high end science).
- German scientist and philosopher Hermann von Helmholtz was probably the first to investigate the properties of vortex motion in the mid 1800s, though even Leonardo DaVinci in the 1500s studied fluid motion and speculated on vortexes.

Encourage students to explain vortexes, and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation. (Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!)

Ask students: "What other kinds of vortexes are there in nature?"

Answer – heaps of them!

- Cyclones
- Tornadoes
- Willi willies
- Dust devils
- Anything moving through air or water makes swirls – including boats and planes.

And we needn't stop on earth; other planets have weather as well!

- The sun spots are vortexes.
- The great red spot on Jupiter is a cyclone that has been raging for at least 300 years!
- Planetary accretion discs (i.e., Saturn's rings) are similar to vortexes.
- A black hole swallowing another star creates a vortex.

Ask: So how do vortexes work?

Explain

Remember – air never sucks, it always pushes.

What is a vortex? (Wikipedia)

"In fluid dynamics, a vortex (plural vortices or vortexes[1][2]) is a region in a fluid in which the flow revolves around an axis line, which may be straight or curved.[3][4] Vortices form in stirred fluids, and may be observed in phenomena such as smoke rings, whirlpools in the wake of boat, or the winds surrounding a tornado or dust devil."

That is to say;

1/ Vortexes form when a liquid or gas spins very quickly around a central line. That line may not even be straight; it can be a curve, wobble, or even a complete circle!

2/ Some examples of vortexes include smoke rings, whirlpools in the wake of boat, tornados, or dust devils. They also include underwater bubble rings, whirlpools in tidal bays, cyclones, and hurricanes. There is a polar vortex – a large scale but usually quite gentle cyclone at the ends of the earth all year around.

Some interesting notes on vortexes:

- Two nearby vortexes spinning in the same direction will eventually combine and form one big vortex (for example, the little vortexes along a wing's edge combine to form a large one on the wingtip). Two nearby vortexes spinning in opposite directions tend to stay apart, 'bumping' off each other. (For example, the two vortexes from each wing tip on the plane tend to stay separate.)
- What is the shape of a tornado called? A Hyperboloid – or "Gabriel's Horn" by Evangelista Torricelli (who helped us come up with the idea of air pressure).
- The centre of the vortex has the lowest pressure, and nearby material flows towards the centre, getting faster and faster the closer it gets. The pressure outside the vortex keeps it tightly wound up. For example, wind tends to rush towards the centre of the cyclone. It does not 'suck', air is pushed in from behind. Where the pressure is low, air will push into that space.

Vortex bottle science

Both water and air have 'pressure', which means they are both pushing in all directions all the time. In our vortex bottle, the air in the bubbles is pushing the water outwards, and air has a surprisingly large amount of push! The water pressure is also pushing the bubbles inward, but as the water spins it loses pressure in the middle, so the bubbles all join together and push their way on through!

Deadly Vortexes: Cyclones

What is a cyclone, typhoon or hurricane?

Short answer: a very large vortex.

Long answer: Watch the video on cyclones or here, and discuss with students.

How a cyclone forms

- Start with still, warm water (i.e., ~27^{O}C).
- The water heats the air, and hot air rises.
- Air moves in to fill the gap left by the rising hot, moist air.
- As the rising, moist air cools; it forms clouds, sometimes 10 kilometres high.
- As rain drops form, heat is released back into the atmosphere, allowing the cycle to continue. Clouds can grow even higher, up to 15 kilometres.
- The air begins to spiral around the centre of the storm. The rising air turns clockwise in the Southern Hemisphere and anticlockwise in the Northern, due to the Coriolis Effect (which DOES NOT affect the direction of water down a bath or toilet[1]). If there's enough heat and humidity a vortex will begin to form.
    - The very centre of the storm is known as the Eye. Some of the now high pressure, dry air will fall downwards in the centre to form the eye of the storm. It is usally clear skies and very calm winds.
    - The eye wall is the most destructive area, with winds up to 200kmph (though 345 kmph was recorded with Hurricane Patricia in 2015).
- Once a cyclone moves over the land it loses its main source of energy (warm ocean water) and begins to fall apart and turn into a normal storm.

Why can we see tornadoes?

The extremely low pressure in the centre of the tornado causes clouds to form, just as we saw in the cloud activity!

This low pressure can also draw up piles of dust, or huge water columns if the tornado touches down near water (a bit like a storm surge).

Elaborate

- Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

[1] A note on the Coriolis Effect: This DOES NOT affect the direction water goes down a plug. You have to be very BIG for the rotation of the earth to affect the direction something spins – as big, say, as the weather. Missiles must also account for the turning of the earth to hit their targets.

Making Vortexes and Tori

Set up a splash tank and have students make tori, eddies, and vortexes[2]. See also activity in appendix.

- Try adding a drop of colour to see if students can make out the gentle movement of the half-Torus (a special "U" shaped vortex).

Cyclone Fun Facts

- Cyclones are given names in alphabetical order as they appear each year. If a cyclone kills people, that name is never used again.
- The wind does not suck you into a vortex; it pushes from behind you towards the centre of the storm.
- The extreme low pressure causes humidity in the air to form drops, making the storm very visible.
- Even if wind tends to move towards the equator, since the air there is rising, cyclones always move away from the equator, due to their spin. They rarely make it all the way to the temperate zones because the water is too cool to power them by then.
- If two cyclones bump into each other, they join power and become even larger (since they are all spinning the same way in each hemisphere).
- Cyclones cannot cross the equator, because then they would have to start rotating in a different direction, falling apart completely first. Wind typically does not cross the equator.

The effects of cyclones, tornadoes and hurricanes:

How they harm

- They can turn even trivial objects into deadly projectiles. Their extreme low pressure causes very fast and damaging winds, usually around 200 kmph, the fastest ever was recorded at 350kmph.
- The wind causes huge, very damaging waves.
- Their extreme low pressure can cause massive storm surges several meters high.
- Once the flooding kicks in there's a whole new class of trouble…
- The wind, rushing so fast and changing direction rapidly, can cause several points of high pressure right next to lower pressure, making things 'explode' into the low pressure zones. Roofs ripped of houses are usually the result of this. As air speeds up on its way past a house, with the help of gravity, the air inside the roof now has more pressure, and can blow up and lift off the tiles, sometimes even the whole roof.

How they help

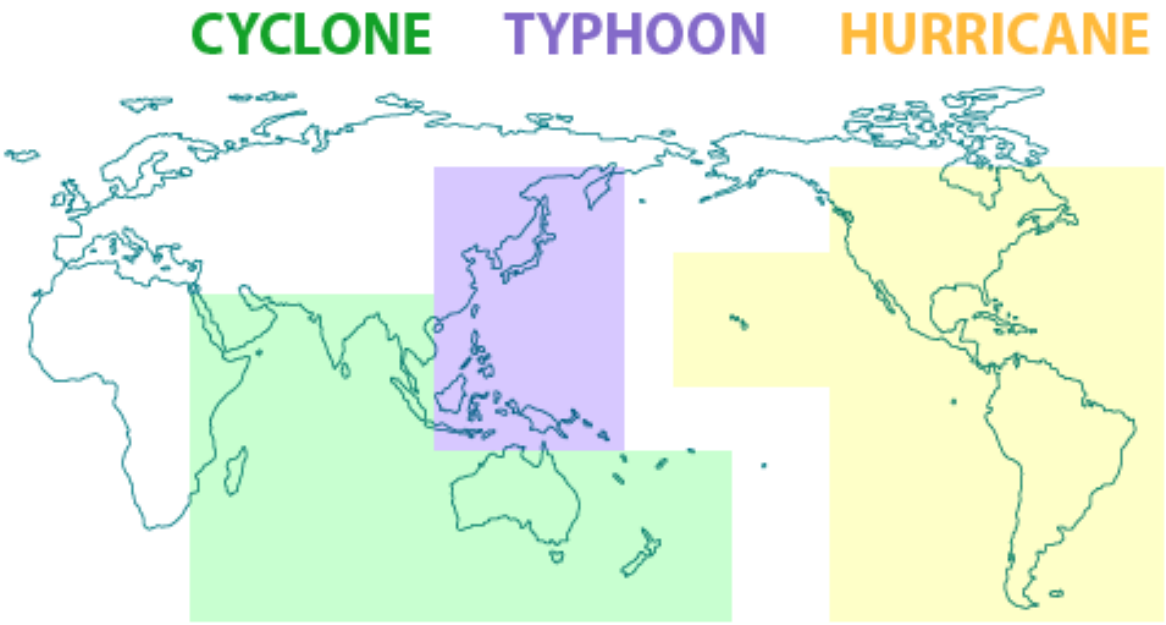
- They perform a vital role in moving heat from the equator towards the poles, making both a liveable temperature for certain forms of life.
- They can disperse life to new areas.
- They can clear away ground or land for new species to take advantage of.

[2] See the video at Creating Science.

- They cause rain in faraway places that might not get rain in any other way.
- People can come together to help each other and rebuild.

What is the difference between hurricanes, cyclones, and typhoons?

Geography – they're just whatever the locals call them, and that's it!



Evaluate

- Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

- Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- ⇨ Did you achieve your learning goal?
- ⇨ What did You learn?
- ⇨ What worked to help you achieve it?
- ⇨ What might you do better next time?
- ⇨ (If needed) where can you go for extra help or information?

Assessment

Prior learning:

As students explore the vortex bottles and fog, note their conversations about their observations. Find out what students already know about vortexes and cyclones.

Formative:

Ask students:

- How can cyclones help? [Spread out heat and lifeforms across earth.]
- Can a vortex form completely underwater? [Yup]
- What would happen if the water underneath the cyclone suddenly became the same temperature as the air inside the cyclone? [It would stop]
- What causes the cyclones in the northern hemisphere to spin the opposite direction to the ones in the southern hemisphere? [The turning of the Earth]

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

- Consider demonstrating the vortex bottle and explaining the science within.
- Design a 3D model of a cyclone and explain how it works.
- Present a report on not only the most damaging storms in Australia, but how they can help as well.

So what?

Cyclones and other natural vortexes are to be respected, but not feared. Know the real causes and dangers of a cyclone, and how to avoid and prepare for them.

Creating science

Science content

As we learned about weather, we learnt that big vortexes such as cyclones can change the earth;

- Earth and Space sciences, Y6: Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096),
- Earth and Space sciences, Y4: Earth's surface changes over time as a result of natural processes and human activity (ACSSU075),
- Earth and Space sciences, Y1: Observable changes occur in the sky and landscape (ACSSU019))

And in discussing how forces can change the motion of the air as hot air rises and cold air falls, we were working on;

- Physical sciences 2,3,4.

Science inquiry skills

Making vortexes and eddy currents models we had the chance to;

- Planning and conducting year 2: Participate in guided investigations to explore and answer questions (ACSIS038)

Science as a human endeavour

As we saw that science can be used to explain, and predict, weather events such as cyclones. We saw how;

- Year 2: Nature and development of science, Science involves observing, asking questions about, and describing changes in, objects and events (ACSHE034)

As we were using science to help make decisions about where to build communities, and how to build them, in areas of potential flooding or cyclone hazard.

- Use and influence of science, People use science in their daily lives, including when caring for their environment and living things (ACSHE035)

Other curriculum areas

Exploring the causes impacts and responses to a cyclone in Australia taught us about;

- Humanities and social sciences, Y7: 'Water in the World' - Causes, impacts and responses to an atmospheric or hydrological hazard (ACHGK042)

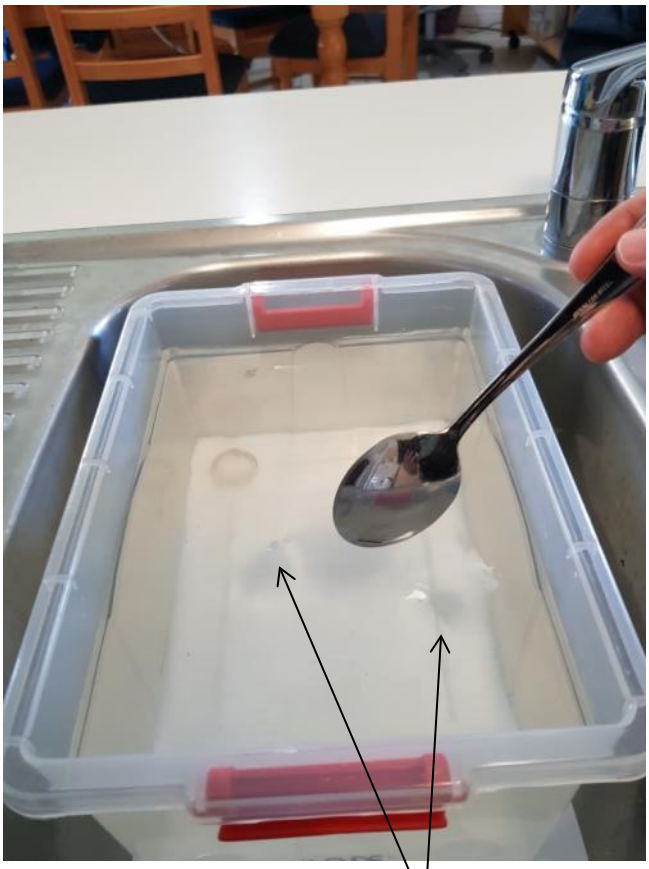
Appendix – Vortex Tank Activity

You'll need:

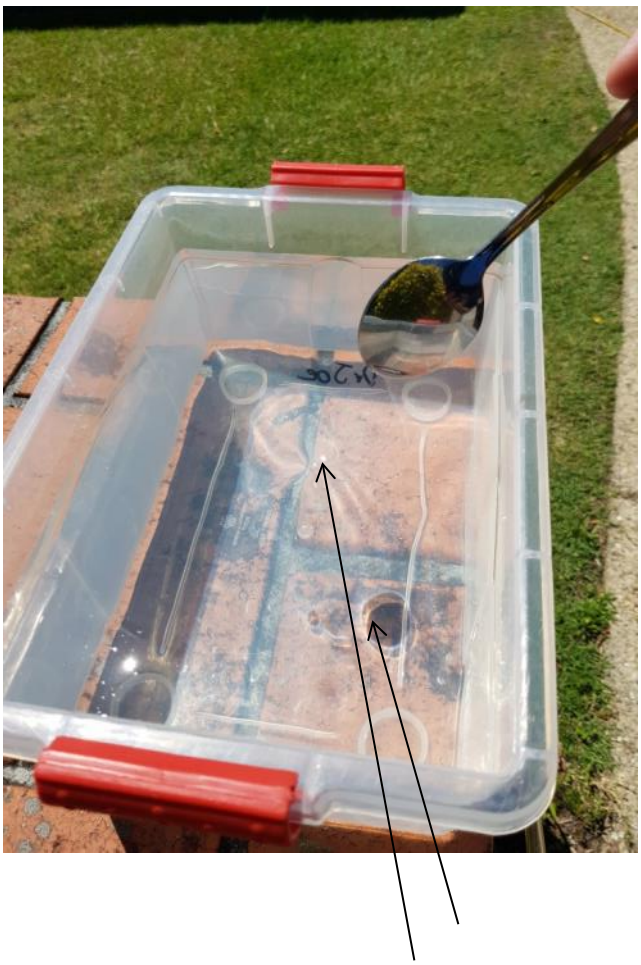
- 1 deep tub of water per 2 students
- 1 spoon per student.

Activity:

- Gently run the spoon a short distance in the tank, and watch the dimples on the surface of the water form as a vortex is created inside the water. The best technique will require patience and practice!
- These two dimples actually link up; underneath the water there is a vortex in a U shape. (The water dimples down because the AIR IN THE ROOM IS PUSHING IT DOWN, and all that effort to spin means the water can't push back up against it as much as it would usually.



Picture 1 – note two vortex shadows in the tub? There's a half torus vortex there for sure!



Picture 2 – One dimple on the surface of the water is clearly visible, and note its shadow is more noticeable in brighter light.