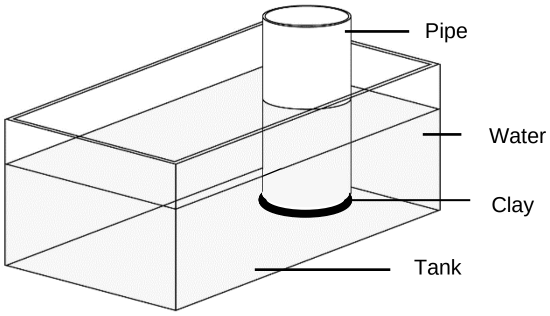
High flow, low flow?: atmosphere and ocean in a tank
Hot, cold and particle-filled density currents as they flow in the atmosphere and ocean

Clouds: http://yotophoto.com/search?page=10&kw=clouds

The set up
Half fill a transparent container with water (any size container will do – but the bigger the better – a plastic fish tank is ideal). Stand a piece of pipe, or something similar, at one end, as in the diagram.



The demonstration is more effective if a circular ribbon of clay or Blu Tak™ is used as a seal between the pipe and the base of the tank – but this is not essential.

Hot current
Boil water and pour some (e.g. about a quarter of a cupful) into a cup or similar container. Add some dye so that the water can be seen when it is added to the tank. Red-coloured dye is best (since the water is hot), but any dye will do, e.g. food dye, ink, coffee, tea. Pour the dyed water into the pipe, stir the water in the pipe, then still it by stirring in the opposite direction. Then slowly and carefully remove the pipe and observe the effect.

The hot water will rise and then flow across the top, hitting the far side and 'bouncing back'. This hot layer can remain at the surface for some time – perhaps more than an hour.

Cold current
Leaving the hot layer as undisturbed as possible, repeat the demonstration with cold water. Pour cold water from a mixture of ice and water into a separate cup and add dye (e.g. blue – cold).

When the pipe is removed, the cold water sinks and flows along the base of the tank, hitting the far side and bouncing back to form a stable layer at the base of the tank.

Milk current
Again, leaving the layers as undisturbed as possible, repeat the demonstration using milk.

The milk flows in a billowing cloud along the base of the tank, under the cold layer, bounces and forms another stable layer at the base of the tank.

To the real world
If the tank were representing the ocean:
- the hot water would be a warm current, flowing across the ocean surface like the North Atlantic Drift (or Gulf Stream) or like the warm surface waters in the Pacific Ocean during the El Niño effect;
- the cold water would be a cold current, as generated near the poles, that flows down and across the deep ocean floors;
- the milk would be a turbidity current, like the currents of water with sand and mud triggered by earthquakes, that flow down continental slopes and across thousands of km^2 of ocean floors.

If the tank were representing the atmosphere:
- the rising hot 'air' would be a low pressure area, with the hot 'air' flowing across the upper atmosphere;
- the sinking cold 'air' would be a high pressure area, with the cold 'air' flowing across the 'land surface' (base of tank) as 'wind'. As the cold 'air' flows across the foot of the tank, it displaces the warm 'air', like a cold front.
- the milk is like the density currents of solid particles in air produced by avalanches (ice crystals in air), volcanic nuées ardentes (white hot ash in air) or collapsing buildings, such as the Twin Towers of the World Trade Centre (dust in air).

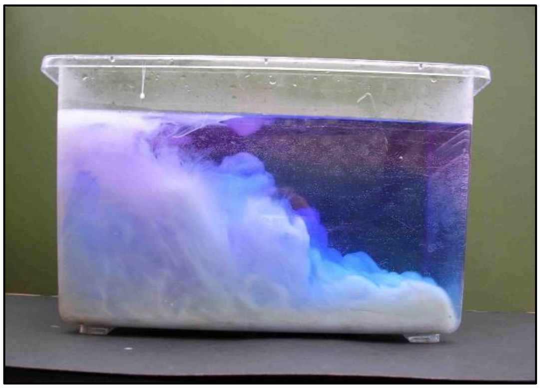
An interactive approach
Pupils become much more involved and watch much more closely if they are asked to predict what will happen before each demonstration. They also learn more effectively that the results are controlled by density, and that the density 'ladder' eventually produced is: milk, most dense; cold dyed water, less dense; clear room-temperature water, even less dense; hot dyed water, least dense.

The back up

Title: High flow, low flow?: atmosphere and ocean in a tank

Subtitle: Hot, cold and particle-filled density currents as they flow in the atmosphere and ocean

Topic: A demonstration of how density currents flow in a tank of water, used as an analogy to the oceans and atmosphere.



The tank in action. (*Peter Kennett).*

Age range of pupils: 10 – 18 years

Time needed to complete activity: 20 mins

Pupil learning outcomes: Pupils can:
- describe and explain what will happen to: a hot body of fluid within cooler fluid; a cold body of water within a warmer fluid; a denser particle-rich fluid within a less dense fluid;
- describe how fluids of different densities can form discrete and separate bodies;
- use the demonstration to explain ocean processes: warm currents; cold currents; turbidity currents;
- use the demonstration to explain atmospheric processes: rising warm air low pressure areas, sinking cold air high pressure areas; wind; cold fronts; avalanches, nuées ardentes and dust density currents.

Context:
This activity can be used to introduce or reinforce understanding of atmospheric and/or ocean processes or, if used interactively, as an effective way of developing thinking skills, as outlined below.

Following up the activity:
Ask what will happen to dyed salty water if added to the apparatus. The salt water may be even denser than the milk, and flow along the bottom. This is why, in estuaries, a layer of fresh water is often found above a wedge of salt water beneath.

Ask what might happen in a pond to hot and cold water at different times of the year, and to muddy water introduced by a stream during a storm.

Ask why 'heat rises'. What phrase would describe what happens to 'cold'?

Underlying principles:
- Less dense fluids rise above and 'float on' less dense fluids.
- Bodies of fluid retain their integrity for long times, days and weeks in the context of the atmosphere and oceans.
- Much of vertical atmospheric and oceanic circulation is controlled by the different densities of the fluids involved, and much of this is controlled by their relative temperatures.

Thinking skill development:
A 'pattern' is constructed of water density and its effects being controlled by temperature; when milk is introduced (of unknown composition and so unknown effect), this causes cognitive conflict, and most think it will flow along the middle or top of the tank. Carefully controlled discussion involves 'metacognition' and then 'bridging' takes place from the tank to the real world of atmosphere and ocean.

Resource list:
- a transparent container – a plastic or glass fish or reptile tank is ideal, but any container, such as used in food packaging or food storage can be used; rectangular containers are best
- a piece of pipe or plastic tubing or a plastic cup with the base removed
- clay, modelling clay or Blu Tak™ as a seal (optional)
- three containers (e.g. cups, beakers)
- dye (e.g. food dye, ink, coffee or tea)
- boiling water
- ice
- water
- stirring rod

Useful links:
See, for the atmosphere:
https://www.metoffice.gov.uk/weather/learn-about/weather/atmosphere/global-circulation-patterns
and for the oceans:
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_1.html

Source:
King, C. & York P. (1995) *'Atmosphere and ocean in motion'* in *Investigating the Science of the Earth, SoE1: Changes to the atmosphere*. Sheffield: Earth Science Teachers' Association, GeoSupplies.