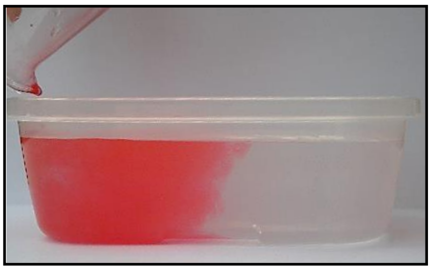
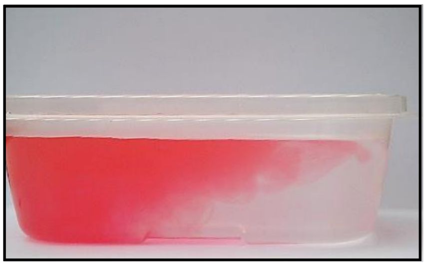
Atmosphere and ocean in a lunchbox
A model for all pupils – of hot, cold and cloudy density currents

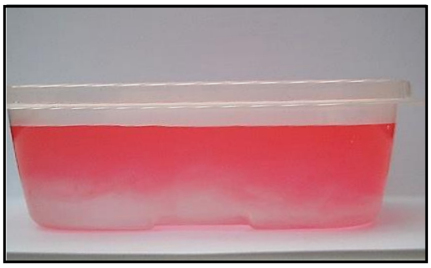
You can demonstrate hot, cold and cloudy density currents, as in the Earth's atmosphere and oceans by using a tank, as shown in the '*High flow, low flow?: atmosphere and ocean in a tank'*, Earthlearningidea …
…. or, you can ask groups of pupils to model these currents for themselves in a lunchbox or small food container

Ask them to fill their lunchbox to near the top with water and then to test their model with:

A hot current
First ask them to predict what will happen when red-coloured hot water is added to the water in their lunch box. Then ask them to collect recently-boiled water from a kettle in their plastic cup. WARNING: burning and scalding danger. They should colour their hot water red, stir it, pour it into one end of their container and watch what happens – the flow will be as seen in the photos below:







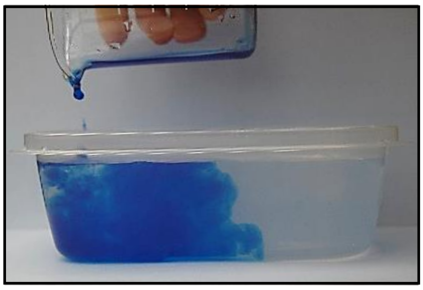
Near-boiling water, coloured with washable red paint, added to the left of the lunchbox – flowing along the top from left to right.

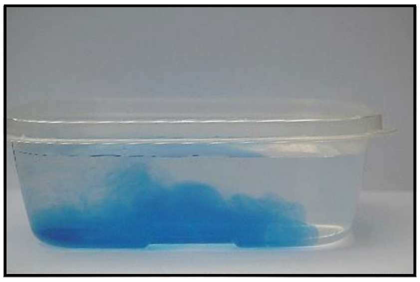
- Ask why the current flows along the top and does not mix with the cooler water below.
  A. Hot water (even when mixed with a little red colouring) is less dense than the cooler water below – and so flows along the upper surface.

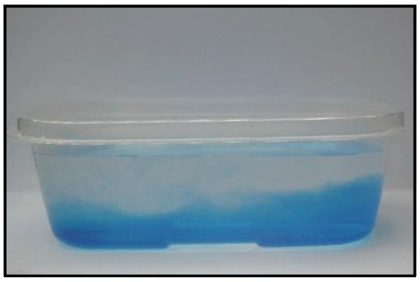
- Ask where this might occur in the oceans.
  A. The warm Gulf Stream or North Atlantic Drift current flows north east from the Caribbean Sea towards Northern Europe across the surface of the Atlantic Ocean; meanwhile, in the El Niño effect, a warm water current flows across the surface of the southern Pacific Ocean from west to east.

- Ask where this might occur in the atmosphere.
  A. Warm air from the Earth's surface rises in small-scale thermals. When larger bodies of warm air rise, they cause low pressure at the Earth's surface and rise into spinning cyclones; when the air reaches the upper atmosphere it flows outwards.

A cold current
Using what they have learned from the first run, they should predict what will happen when cold water, coloured blue, is added. Ask them to refill their lunchbox with clean water, collect some ice-cold water (without ice cubes), colour it blue, add it to the lunchbox and watch the result.







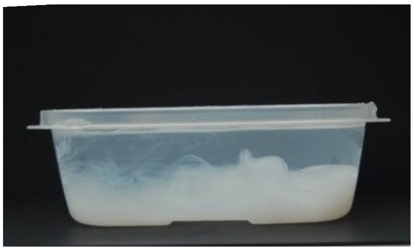
Iced water, coloured with blue food colouring, added to the left of the lunchbox – flowing along the bottom from left to right.

- Ask why the cold current flows along the bottom. *A. Because it is more dense than the warmer water above.*

- Ask where this might occur in the oceans. *A. Cold water sinks in polar areas of the oceans and flows across the deep sea floor before upwelling nearer the Equator; this upwelling brings nutrients to the surface, so these areas are very rich in sea life.*

- Ask where this might occur in the atmosphere. *A. Cold dense air sinks in anticyclones producing high pressure at the Earth's surface. When the cold air reaches the ground, it spills over the ground surface; this air flow is called wind. The 'front' or boundary between the flowing cold water in the model and the warmer water is a cold front.*

A current with particles
Using what they have learned, ask what they think will happen when they add a current of milk, in the same way as before. Then ask them to refill their box with clean water and try it, to find out what does happen. *A. Many people think that, because milk contains fat, it will flow along the top.*



Milk added to the left of the lunchbox
– flowing along the bottom from left to right.

- Ask why the milk flows along the bottom. *A. Milk is an emulsion of fat and water which is denser than water; this is why it flows along the bottom.*

- Ask where this might occur in the ocean. *A. Sand and mud settle and build up at the top of the continental slope; when an earthquake triggers a slump in the sediment, it flows down the slope in a density current and then out across millions of km^2 of deep ocean floor, depositing sand and mud as it flows; these density flows are called turbidity currents.*

- Ask where this might happen in the air. *A. Currents of air which are denser than normal air, because of the fine particles in them, include:*
  - *dust storms;*
  - *ice/snow avalanches of particles of ice/snow in air;*
  - *nuée ardentes, or glowing clouds of ash flowing down the sides of volcanoes during explosive eruptions;*
  - *the cloud of dust from the collapsing Twin Towers of the World Trade Centre;*
  - *the base surge of nuclear explosions.*

Does the colour matter?
Ask what would happen if the water were coloured by different coloured dyes. *A. The colour of the dye makes no difference, it is the density of the current which controls what happens.*

A current of ice-cold water coloured by coffee.

All lunch box photos by Chris King.

The back up

Title: Atmosphere and ocean in a lunchbox.

Subtitle: A model for all pupils – of hot, cold and cloudy density currents.

Topic: The teacher demonstration of density currents in a tank in the '*Atmosphere and ocean in a tank*' Earthlearningidea developed into a smaller-scale model for pupil group use.

Age range of pupils: 14 years upwards

Time needed to complete activity: 20 minutes

Pupil learning outcomes: Pupils can:

- describe and explain what will happen to: a hot body of fluid within cooler fluid; a cold body of fluid 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.

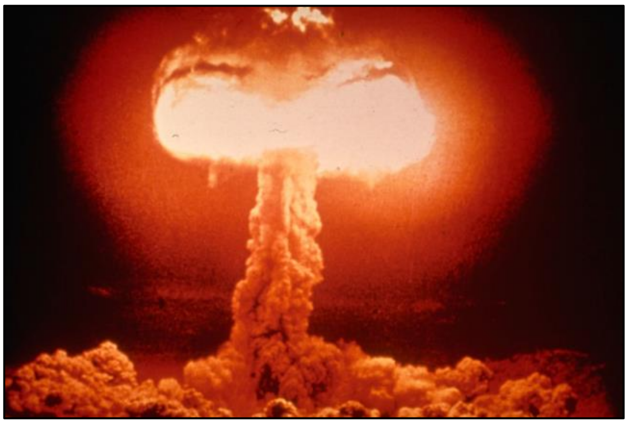
Density currents of fine particles in air are shown in the photos below:

A dust storm in Iraq.

An avalanche.

A nuée ardente flowing down Mayon Volcano.

Dust cloud from the collapse of the World Trade Centre.



The base surge of a nuclear explosion at night.

This image is a work of a Federal Emergency Management Agency employee; all FEMA images are in the public domain.

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.
A. Pond and lake water can become stratified, with a layer of warm water at the surface or a layer of cold water at depth; muddy water can flow across the bottoms of lakes or ponds as density currents.

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

Underlying principles:
- Less dense fluids rise above and ‘float on’ more dense fluids.
- Bodies of fluid retain their integrity for long times, sometimes 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:
- transparent food container or lunchbox per group
- 2 plastic cups (one inside the other, for insulation) or beaker per group
- dye e.g. washable paint, food dye or ink (Note that these will stain fingers), coffee or tea
- stirrer, e.g. a pencil
- boiling water, e.g. from a kettle
- ice to make iced water
- milk (any type will do)
- water

Useful links:
See, for the atmosphere:
http://www.ucar.edu/learn/1_1_1.htm
And for the oceans:
http://www.noaa.gov/resource-collections/ocean-currents

Source: Modified from 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 Ltd.