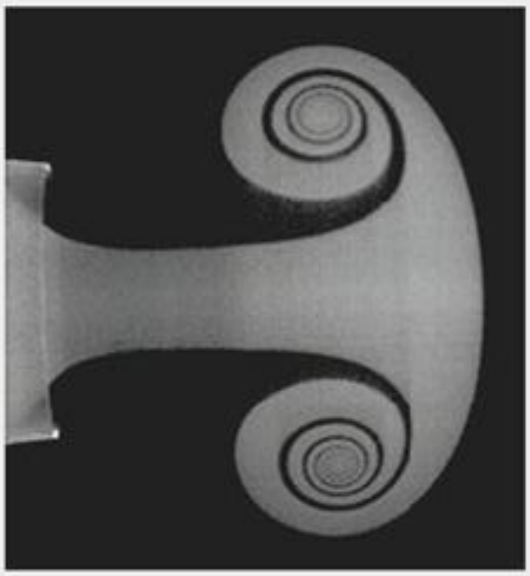
Vortex Ring

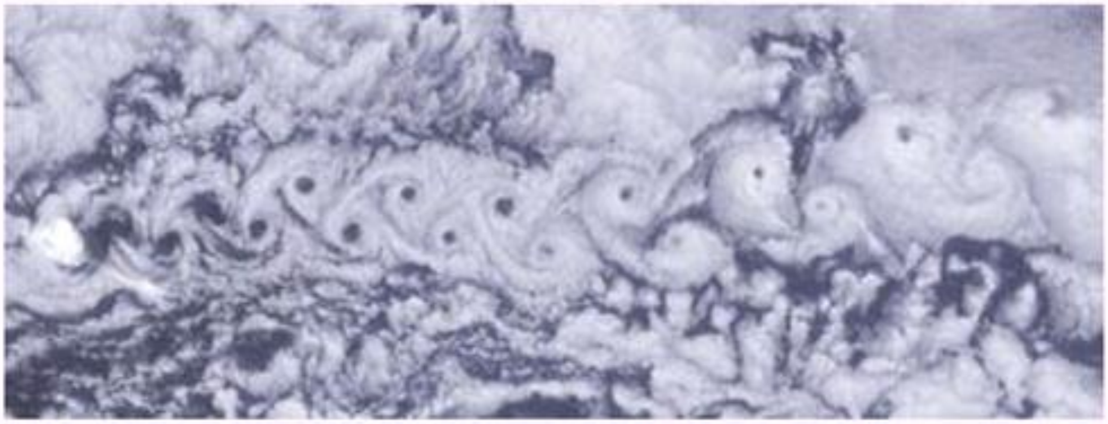
Dolphins create vortex rings to play with by exhaling through their blowholes. The sharp impulse of air, combined with the round shape, creates a vortex ring of bubbles.



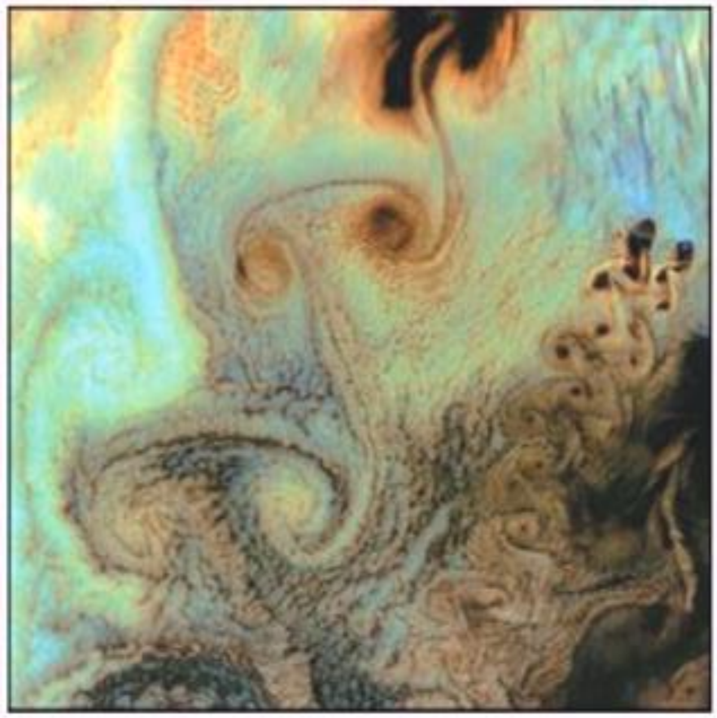
Vortex rings (commonly known as smoke rings) can be formed by sudden ejection of fluid from a tube or orifice. During ejection, the jet rolls up into a toroidal spiral (ring) and in the process, entrains some of the ambient fluid into the spiral. Unlike a sea wave, a moving vortex ring actually carries the spinning fluid along. Thus, a vortex ring can carry mass much further and with less dispersion than a jet of fluid. That explains, for instance, why a smoke ring keeps traveling long after any extra smoke blown out with it has stopped and dispersed

Mount Etna on 11th March 2000. At this time the volcano was blowing numerous smoke rings into the atmosphere. The smoke ring is an example of a vortex ring, where a gas release channeled through the vent of the volcano gives rise to trailing vortex spirals on all sides.

Von Kármán Vortex Street

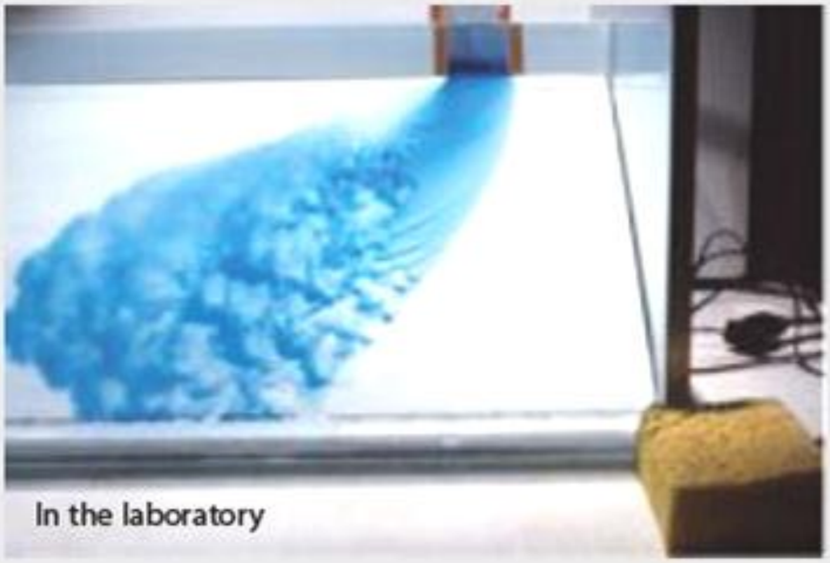


A Von Karman vortex street caused by the airflow over the island of Jan Mayen in the Greenland Sea (above) and over Alaska's Aleutian Islands (right) as seen in satellite imagery



A Von Kármán vortex street is a repeating pattern of swirling vortices caused by the unsteady separation of flow of a fluid around blunt bodies. It is named after the engineer and fluid dynamicist Theodore von Kármán and is responsible for such phenomena as the "singing" of suspended telephone or power lines, and the vibration of a car antenna at certain speeds. A vortex street will only form at a certain range of flow velocities.

Dense Currents



In the laboratory

The descent of dense water from the continental shelves into the deep ocean over the continental slope is an important component of the ocean circulation. During the descent these currents have been observed to entrain the surrounding ambient fluid. The final properties of their water masses are dictated by the amount and properties of the entrained fluid. Avalanches, pyroclastics flows and turbidity currents are other exaples of dense currents.

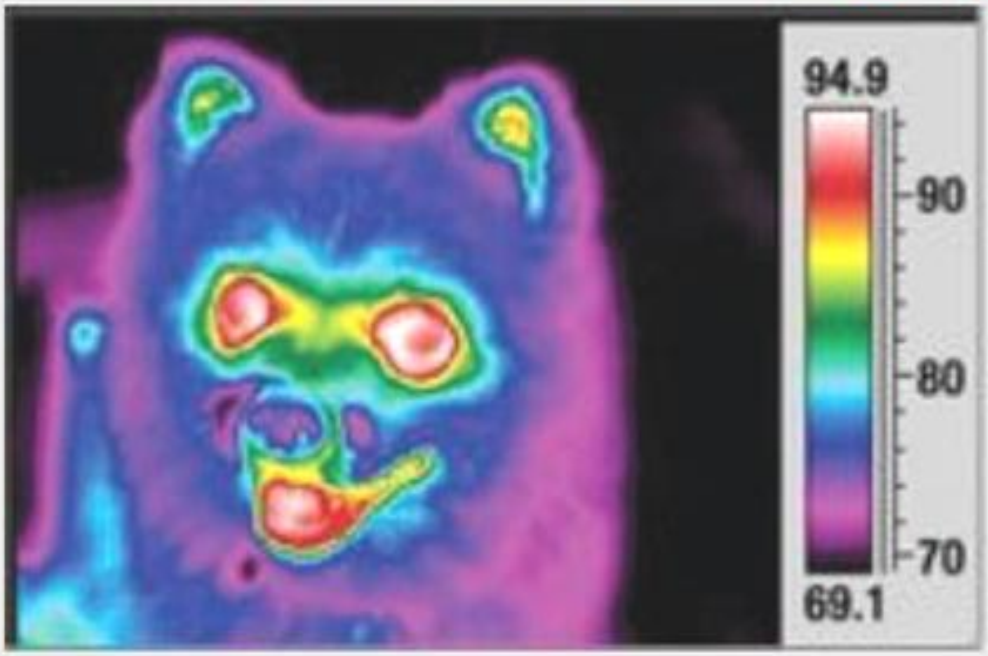
Underwater picture of a turbidity current.

The size of these turbidity currents can differ by many orders of magnitude from small local events to flows travelling hundreds of kilometers.

An avalanche of snow moves suddenly and quickly downslope, burying everything in its path.

Pyroclastic flows sweep down the flanks of Mayon Volcano, Philippines, in 1984.

InfraRed Imagery

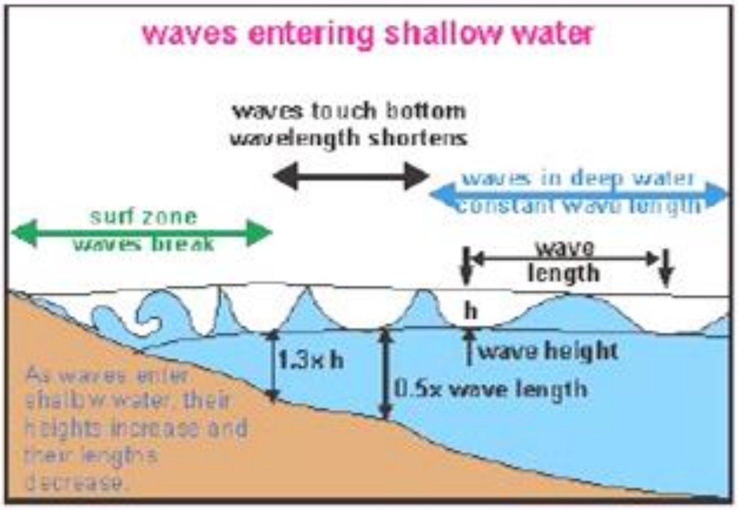


Can you guess which is the coldest part of your face?

All objects emit a certain amount of 'black body' radiation as a function of their temperatures. In general, the higher an object's temperature is, the more infrared radiation is emitted. An infrared camera, or thermographic camera, can detect this radiation in a way similar to the way an ordinary camera detects visible light. It works even in total darkness because ambient light level does not matter. This makes it useful for rescue operations in smoke-filled buildings and underground. Instead of the 450–750 nanometer range of the visible light camera, infrared cameras operate in wavelengths as long as 14,000 nm (14 µm).

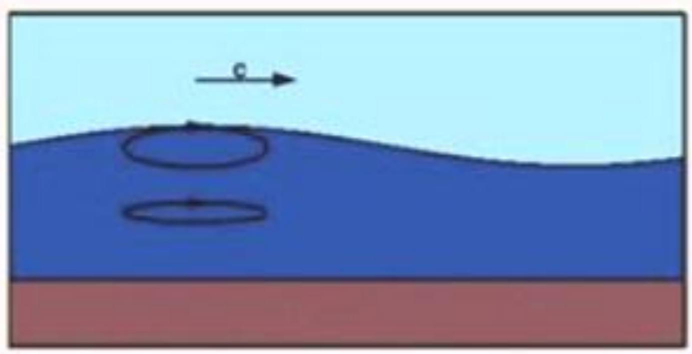
InfraRed imagery is also used for residential building diagnostics. This house is leaking heat through the roof!

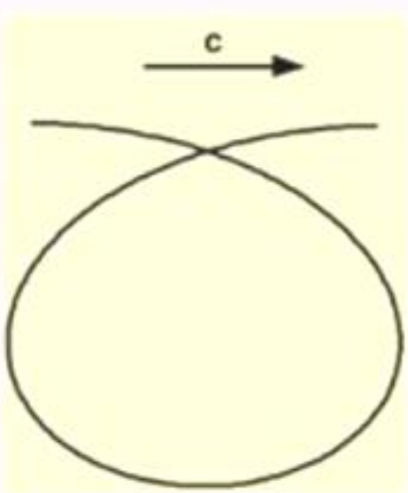
Surface Gravity Waves



The type of wave motion which most people are familiar with are waves that occur on the free surface of water. For example, the ripples that occur when a small rock is dropped into the water or the waves that can be seen breaking on a beach. In this type of wave motion the restoring force is gravity and therefore these waves are known as surface gravity waves.

Pathlines of particles to a first order approximation for waves with a long wave length relative to the depth of the water are (long gravity waves).





STOKES' DRIFT: When looking at waves at the beach you can notice that the waves do not transport things (like seaweed of drift wood) at the same speed at which the crests and troughs of the waves propagate. However, objects still appear to be moving in the direction of wave propagation, albeit a lot slower. This effect is called Stokes' Drift. It is due to second order (nonlinear) effects. Looking at the pathlines of a particle (left) one can see that the pathline for one period is not a closed loop nor does it follow the shape of the wave.

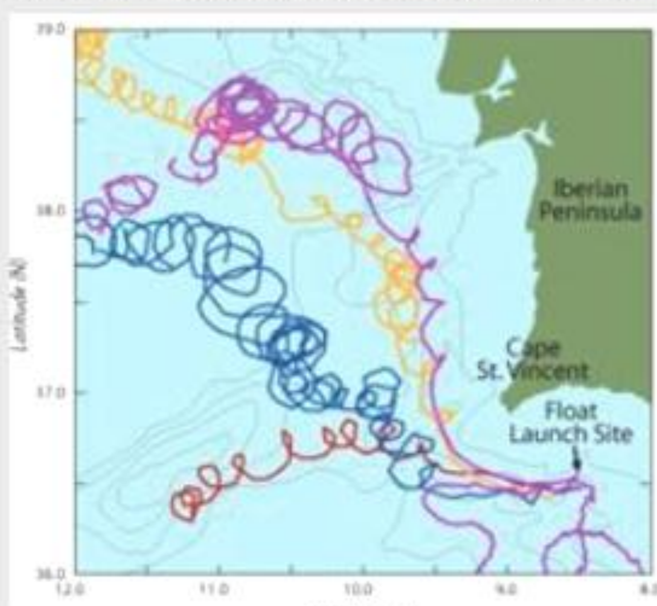
Coastal Currents

Sediments color the buoyant current which flows along the Alaska coastline. Barolcinic instabilities (waves) are visible in the current. August 22, 2003 MODIS instrument aboard NASA's Terra satellite.

Buoyancy-driven coastal currents occur in many parts of the world's oceans. The currents owe their existence to the presence of a coast and hug the coastline with the coast on their right looking downstream (in the northern hemisphere). Satellite images of these currents show that they are unstable, giving rise to meanders (i.e. waves) and the detachment of vortices from the main current. Coastal currents are important because they are responsible for the transport and dispersal of biological, chemical, and geological tracers in the water. For example, predictions of the advection and diffusion of spilled oil is dependent upon knowledge of the currents near the coast.

GENERATION OF EDDIES AT A CAPE

Four different floats trajectories are shown in the formation of Mediterranean vortices also known as "meddies" off the Iberian Peninsula. Near Cape St. Vincent, the floats started looping rapidly in the clockwise direction, indicating that the floats were caught in the formation of new meddies near Cape St. Vincent.



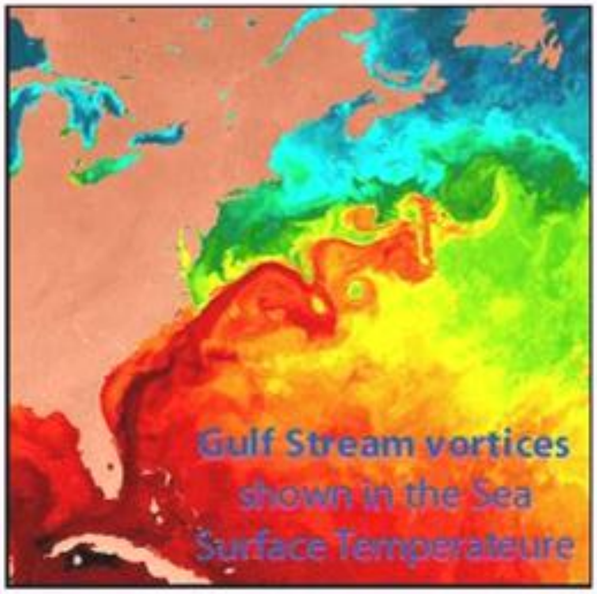
Turbulence and Mixing

Drawing by Leonardo Da Vinci of pouring water creating turbulent flow

Turbulence is not easy to define, but it is a ubiquitous phenomenon. Tobacco smoke, industrial smoke, milk mixed into coffee, all reveal turbulent motion. Whenever fluids are set into motion, turbulence tends to develop. As we experience every day, milk poured into coffee cup shows complex behavior. We stir coffee and milk because we empirically know that turbulence effectively enhances mixing. Turbulent flows have common characteristics, one of the clearest of which is disorder.

Vortices

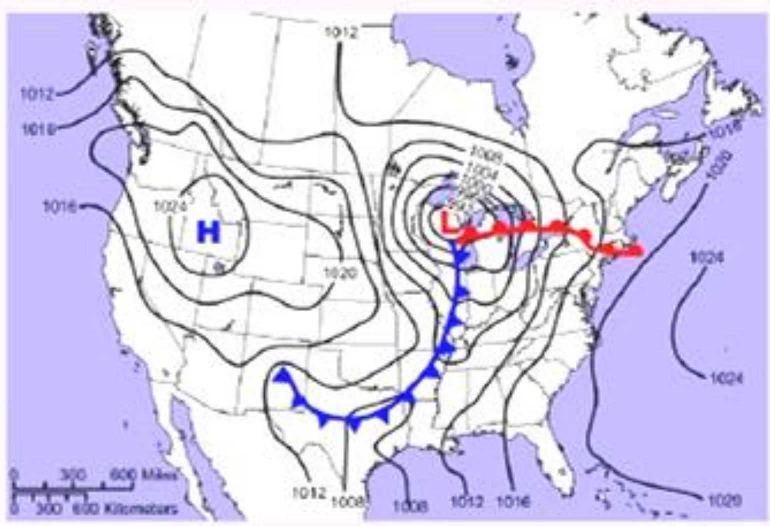
Hurricanes are vortices spinning counterclockwise (cyclones).
Satellite view of the enormous cloud field associated with Hurricane Sandy.



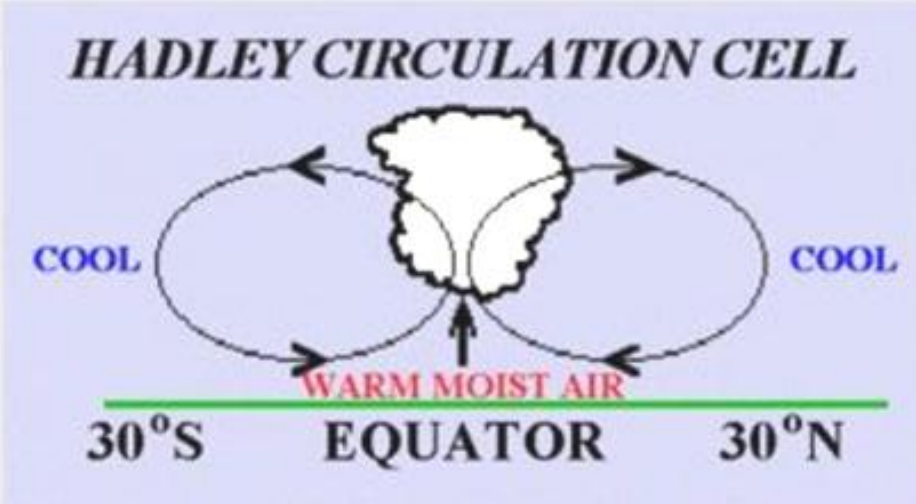
Gulf Stream vortices shown in the Sea Surface Temperateure

A vortex is a region within a fluid where the flow is mostly a spinning motion about an imaginary axis, straight or curved. Vortices are common in the ocean and the atmosphere, and range in diameter from centimeters to a thousand kilometers. The smallest scale eddies may last for a matter of seconds, while the larger features may persist for months to years. Because vortices may have a vigorous circulation associated with them, they are of concern to naval and commercial operations at sea.

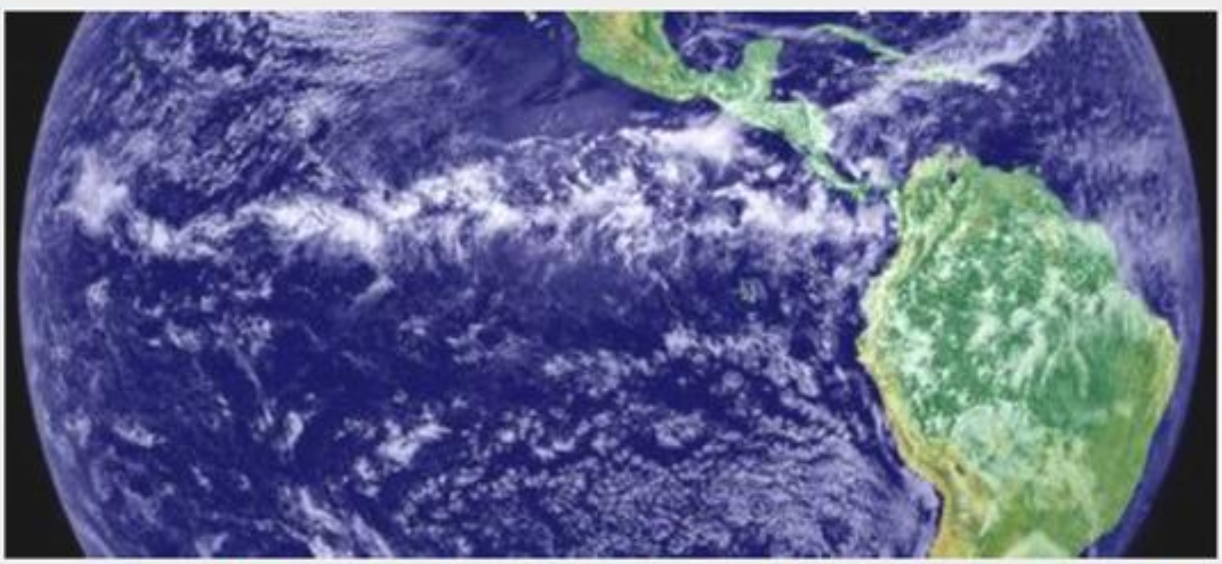
Highs and Lows on weather maps are vortices.
In the Northern Hemisphere, high pressure is associated with a clockwise motion (anticyclones) while low pressure is associated with counterclockwise motion (cyclones).



Hadley cell



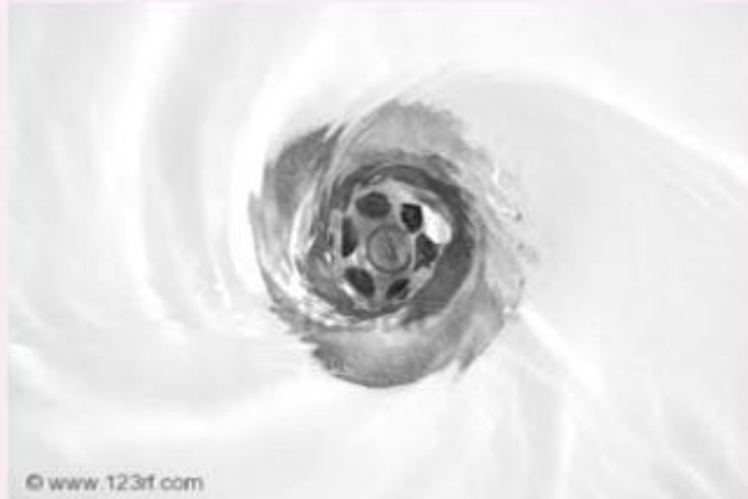
The major driving force of the atmospheric circulation is solar heating, which on average is largest near the equator and smallest at the poles. The atmospheric circulation transports energy polewards, thus reducing the resulting equator-to-pole temperature gradient. The Hadley cell, named after George Hadley, is a tropical atmospheric circulation which features rising motion near the equator (Intertropical Convergence Zone), poleward flow 10–15 kilometers above the surface, descending motion in the subtropics, and equatorward flow near the surface. These flows are also influenced by the Earth rotation and near the surface, the equatorward return flow is turned to the west and is referred to as the trade winds.



The ITCZ's band of clouds over the Eastern Pacific and the Americas as seen from space.

The bath-tub vortex

Question: **Does my bathtub drain differently depending on whether I live in the northern or southern hemisphere?**



Answer: **No. There is a real effect, but it is far too small to be relevant when you pull the plug in your bathtub.**

A tornado near Cherokee, Oklahoma.

Because the Earth rotates, fluid motion is affected by the "Coriolis" acceleration perpendicular to its velocity. In the northern hemisphere, Coriolis acceleration makes low pressure storm systems spin counterclockwise; however, in the southern hemisphere, they spin clockwise because the direction of the Coriolis acceleration is reversed. This large-scale effect leads to the speculation that the small-scale bathtub vortex that you see when you pull the plug from the drain spins one way in the northern hemisphere and the other way in the southern hemisphere.

But this effect is VERY weak for bathtub-scale fluid motions. The effect of the Coriolis acceleration on your bathtub vortex is SMALL. To detect its effect on your bathtub, you would have to get out and wait until the motion in the water is extremely small. This would require removing thermal currents, vibration, and any other sources of noise. Under such conditions, never occurring in the typical home, you WOULD see an effect.