

# **Go with the Flow**

## **FSU 2015**

### **Convection**

### **Ocean Currents**

### **Earth**

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GVSU Geology

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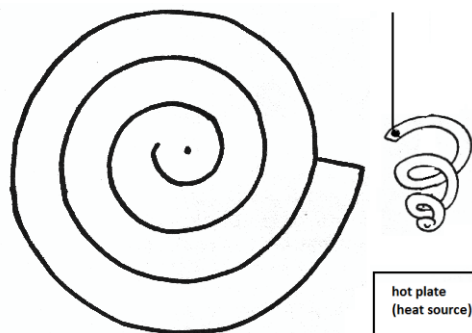
GVSU Physics

## Paper Spiral

Kelly Heid, Geology Department, Grand Valley State University, 2015

**Materials:** heat source (hot plate or candle), scissors, paper, thread

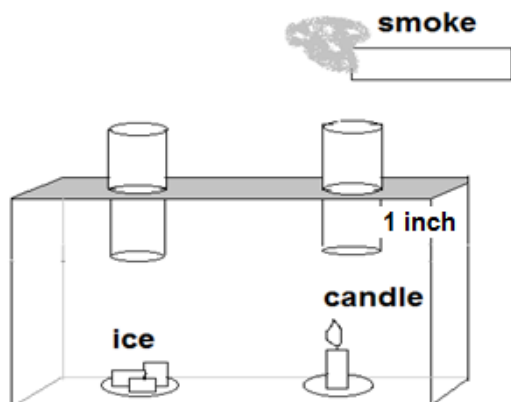
1. Using scissors cut out a paper spiral.  
Punch a small hole in the outer end of the spiral and tie a piece of thread through hole.
2. Hold the spiral above and away from the heat source.



**Why?** The spiral will turn due to the warm rising air. Shows students that even though you can't see the air molecules that they are physically present.

## Convection Current Box:

Kelly Heid, Geology Department, Grand Valley State University, 2015



**Materials:** 5 gallon aquarium, cardboard top, 2 plastic cylinders (paper towel rolls), two jar lids, candle, matches, ice, wizard stick (or tongs and paper towel)

**Set up:** See diagram \*make sure to keep the plastic chimneys high above candle flame so will not melt.

1. Before lighting the candle: Ask students to predict what will happen when you hold the smoke over the candle or the ice.
2. Move the smoke over the candle to show movement and then over the ice.  
Candle will cause smoke to rise.  
Ice will smoke will fall.

**Why:** Warm air is rising above the candle and leaving the tank is create an area of lower air pressure. The area outside the tank hold more air so it is considered an area of higher pressure. So the high pressure pushes new air into the tank above the ice. The ice makes the air denser, making the air above the candle a higher pressure area. The greater the difference in pressure, the greater the pressure gradient and movement.

# Ocean Currents

## Density Currents in a Baggie



**Materials:** baggie of blue colored ice water, baggie of red colored warm/hot water, clear plastic container, scissors

### Procedure:

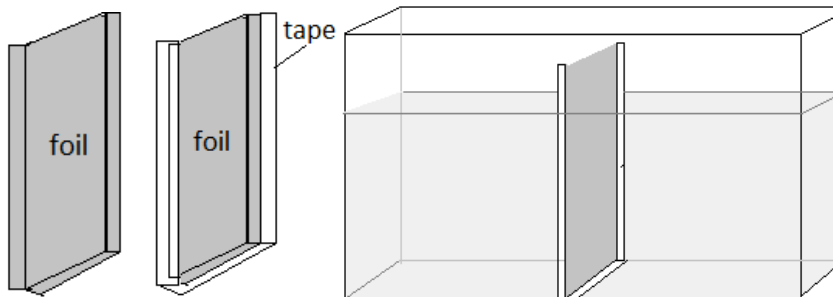
1. Fill container with clear room temperature water.
2. Float cold water baggie on one side of container and the warm baggie on the other.
3. Carefully cut off the corner of both bags and watch what happens to the water within the bags.
4. Have students Draw their observations and discuss.

**Why?** Cold water is denser and sinks while the warm water is less dense and floats at surface.

## Ocean Temperature and Salinity Circulation Currents

Kelly Heid, Geology Department, Grand Valley State University, 2015

**Materials:** 5 or 10 gallon aquarium (tank must be completely dry, 2 large plastic containers, foil, masking tape, salt, food coloring, water, ice, scissors/compass needle or something that will tear foil







### Set up procedure: Make solutions and set up tank before students arrive to class.

1. Take an oversized piece of aluminum foil (it needs to be larger than both sides and bottom of the tank) and position it in the center of the aquarium. Position the edges of the foil so they lay slightly flat against the glass sides and bottom of the tank.
2. Securely tape on side of the foil to one glass side of the dry tank. Take a bit of time to work the corners of the foil at the tank bottom. Tape the bottom and the remaining side of the foil to glass tank. Overlap a second row of masking tape on top of the first to make sure completely sealed so that water cannot seep through.
3. After you have one side of the foil taped to the tank, carefully add masking tape to the other side of the foil to help secure and keep water from leaking through the back side from beneath the foil. This would compromise the tape seal.
4. Place 1/3 cup of salt on each side of tank and slowly add room temperature water to both compartments in the tank until 1/2 of the tank is full. Don't over fill one too much higher than the other as you fill the tank or foil might break.
5. Add blue food coloring to one chamber side and red to the other chamber.

6. On the red side add hot water until the chamber is  $\frac{2}{3}$  full and to the blue side add colder water. Stir to dissolve the salt.
7. Fill one large plastic beaker  $\frac{2}{3}$  full of water and add  $\frac{1}{4}$  cup of salt, stir and continue adding salt until all salt is dissolve (over saturate this solution). Add red and blue to make a dark purple solution and add ice to the beaker.
8. The second solution contains room temperature fresh water with yellow food coloring.
9. The third solution contains contain extra warm room temperature water. Add green coloring to this solution and salt.

### Demonstration Procedure

1. Ask student to predict what will happen to the water if you make a hole in the top and bottom of the foil. Tell the students both sides of the tank are salt water.
2. Carefully poke a large hole in the bottom and then at the top of the foil (try not to disturb water too much. Let the students watch what happens over time.
3. Students should make a sketch and some written observations about what they observe in the tank.
4. Show the students the ice salt water and ask them to predict what should happen when icy salt water is added to the tank. Repeat with the warm fresh water (fresh water at surface) and warm salty water.
5. Ask students to make a hypothesis to explain what happened. (DENSITY)

scenerio	prediction	Sketch	Written Observations
red and blue water			
purple icy salt water			
green warm salt water			
Yellow fresh water			

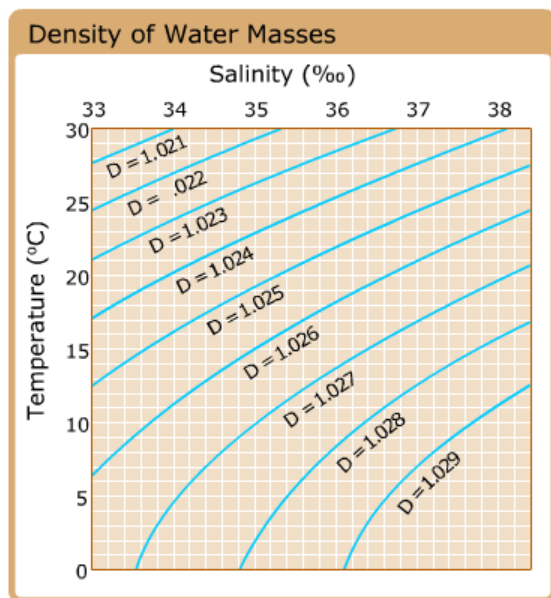
## Extension Activity:

### How Do Temperature and Salinity Affect Mixing in the Oceans?

Exploring the Earth: Investigations, Ch. 22 Water Planet, *How Do Temperature and Salinity Affect Mixing in the Oceans*, CLASSZONE, McDougal Little A Houghton Mifflin Company, 11/2/15

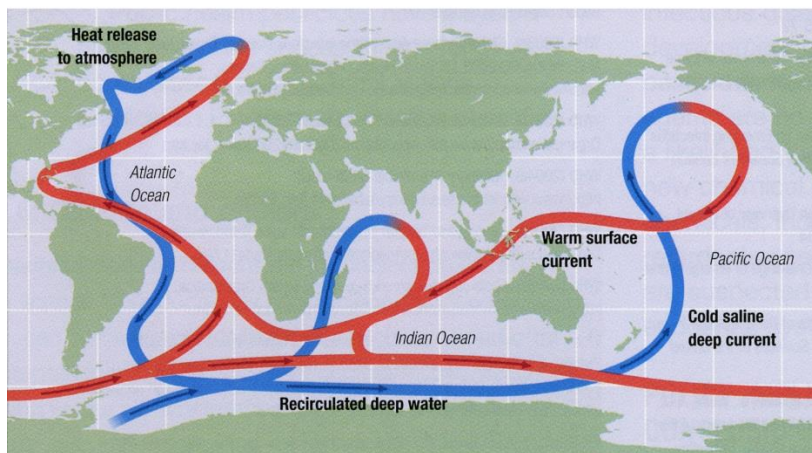
[https://www.classzone.com/books/earth\\_science/terc/content/investigations/es2202/es2202page01.cfm](https://www.classzone.com/books/earth_science/terc/content/investigations/es2202/es2202page01.cfm)

This is a short 6 page online activity that helps students explore the relationships between ocean temperatures and salinities of a few key locations on the Earth's surface. Students compare temperature and salinity maps and use those two variables to determine the density and current flow of the ocean at several locations. Includes some guiding questions to help student focus on what is causing the salinity variations at these locations.



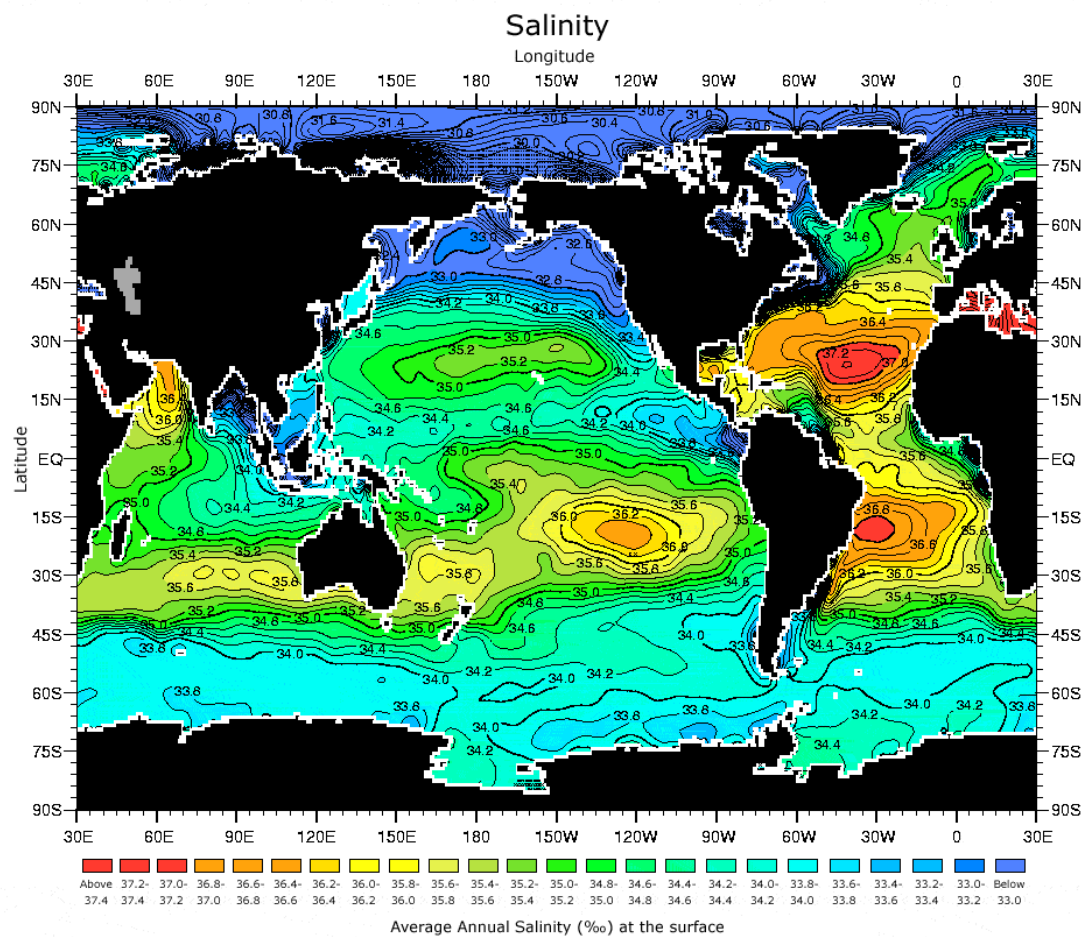
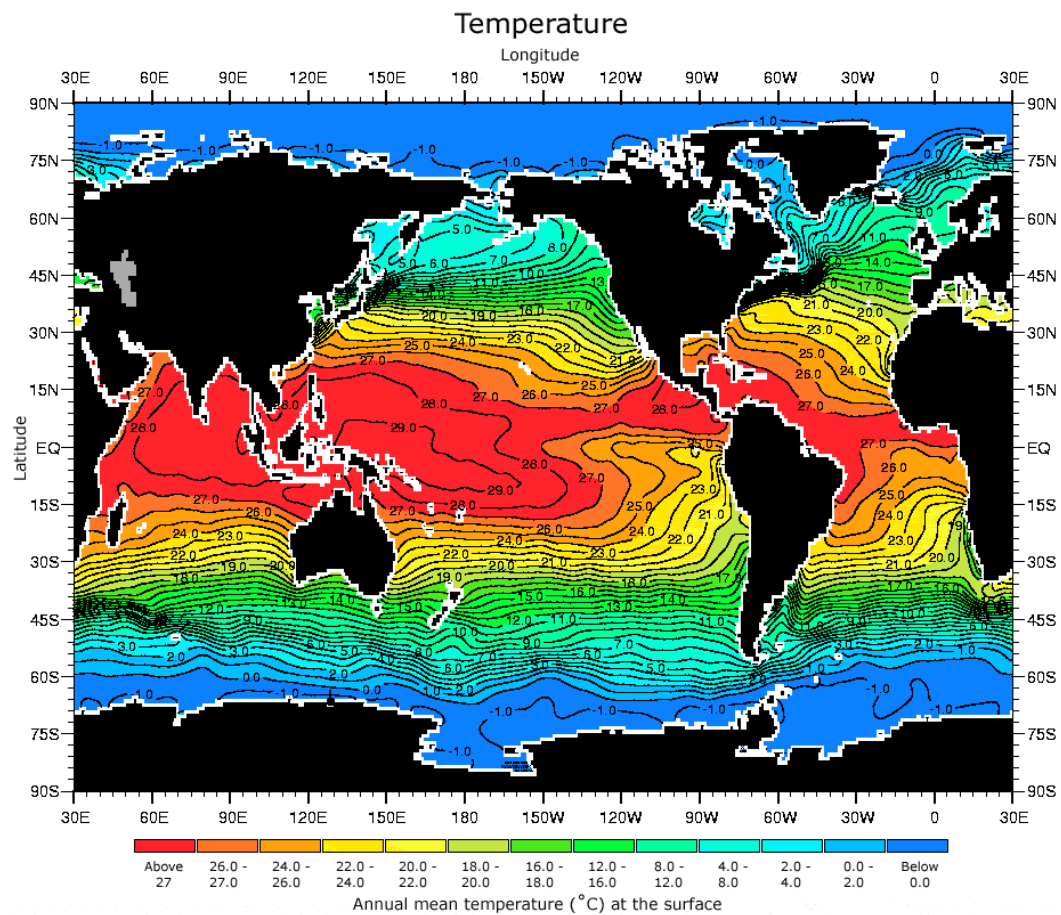
\*note density error second line show read D= 1.022

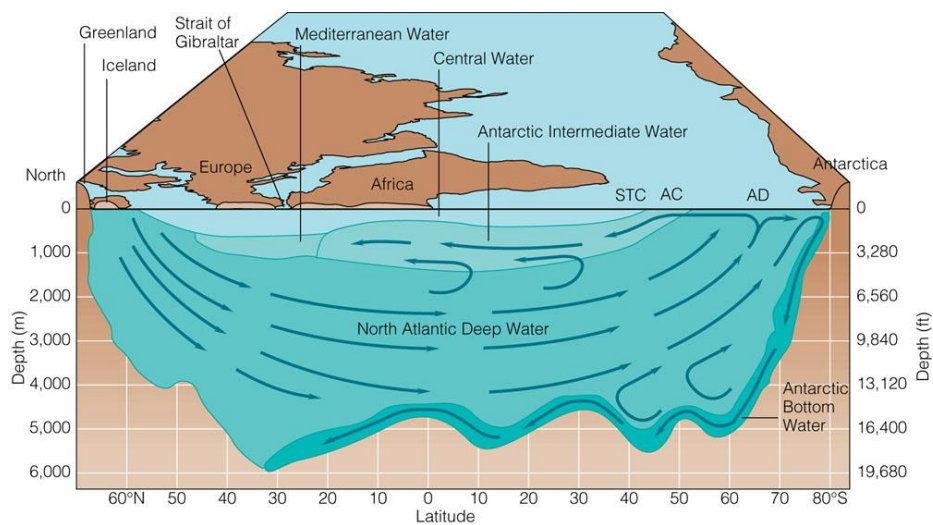
## Global Ocean Conveyor Circulation



Thermohaline circulation

[https://www.google.com/search?q=thermohaline+circulation+antarctica+bottom+current&source=lnms&tbm=isch&sa=X&ved=0CAcQ\\_AUoAWoVChMI6ZO7krSWyQIVQkYmCh20EwAG&biw=1134&bih=608#imgrc=AIRs\\_rKs43w-eM%3A](https://www.google.com/search?q=thermohaline+circulation+antarctica+bottom+current&source=lnms&tbm=isch&sa=X&ved=0CAcQ_AUoAWoVChMI6ZO7krSWyQIVQkYmCh20EwAG&biw=1134&bih=608#imgrc=AIRs_rKs43w-eM%3A)

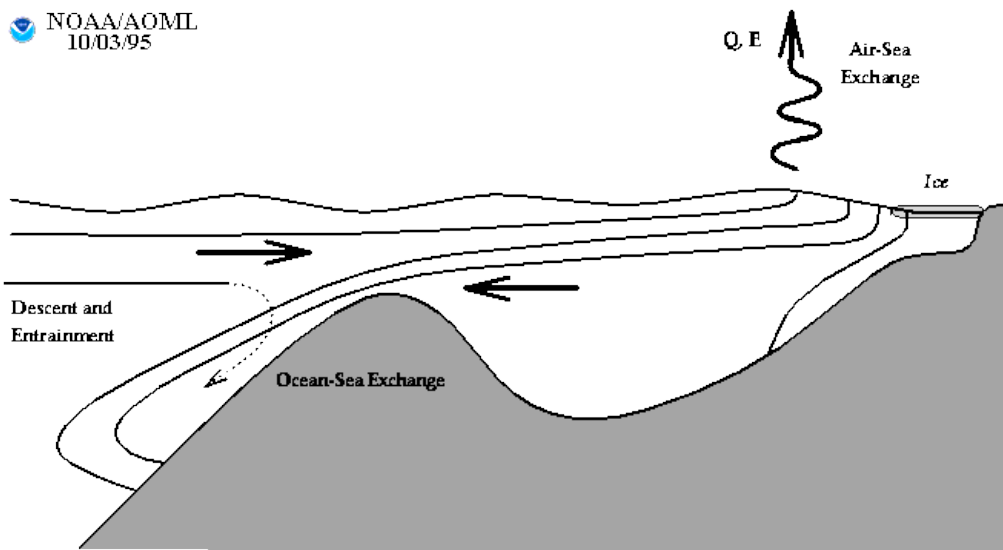




© 2005 Brooks/Cole - Thomson

## Thermohaline Atlantic Ocean cross-section

[https://www.google.com/search?q=thermohaline+circulation+antarctica+bottom+current&source=lnms&tbm=isch&sa=X&ved=0CAcQ\\_AUoAWoVChMI6ZO7krSWyQIVQkYmCh20EwAG&biw=1134&bih=608#imgrc=nzVaysJetriwGM%3A](https://www.google.com/search?q=thermohaline+circulation+antarctica+bottom+current&source=lnms&tbm=isch&sa=X&ved=0CAcQ_AUoAWoVChMI6ZO7krSWyQIVQkYmCh20EwAG&biw=1134&bih=608#imgrc=nzVaysJetriwGM%3A)



Atlantic Ocean surface current moves to the east and the Mediterranean bottom current to the west.

[https://www.google.com/search?q=straits+of+gibraltar+thermohaline+ocean+current&biw=1134&bih=608&source=lnms&tbm=isch&sa=X&ved=0CAYQ\\_AUoAWoVChMI3s6GhLeWyQIVASomCh3-Hwte#imgsrc=K6CcwilrtAMgSM%3A](https://www.google.com/search?q=straits+of+gibraltar+thermohaline+ocean+current&biw=1134&bih=608&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMI3s6GhLeWyQIVASomCh3-Hwte#imgsrc=K6CcwilrtAMgSM%3A)



## **Helpful info, K. Heid:**

**Salinity** measures the amount of dissolved salt in water. The average salinity of ocean water for the Earth's oceans is around 35 grams of dissolved salts per kilogram of ocean water 35‰. (35 parts per thousand).

**High temperatures** – warmer water can hold more salt and the evaporating water does not include the salt = increase salinity

**Low temperatures** – colder water cannot hold as much salt but if water freezes it drops out the salt = increasing in salinity.

**Precipitation** – addition of fresh water = decrease salinity

**Tropics** – the warm temperatures in this area cause high evaporation. The evaporation increases the salt because it is left behind but in this area the high rate of evaporation increases the amount of precipitation over the oceans = addition of fresh which lowers salinity value.

**30°N and 30°S latitude** – these areas on the map display the highest salinity concentrations. This area is an area with warm temperatures and drier air due to global pressure and wind patterns. This area is where the Hadley and Ferrel Convection Cells in the atmosphere meet and where cooler dry air in the atmosphere sinks to creating the global high pressure belt. The drier conditions (low precipitation) and warm temperatures (evaporation) = higher salinity.

### **Specific locations:**

**Mississippi River and Amazon River** add freshwater to oceans = decrease in salinity

**Mediterranean Ocean** – warm temperatures increase evaporation of water in small basin area and is partially within the global high pressure area. High evaporation = increase salinity

**Antarctic Ocean** – as ocean water freezes it drops out salt, the increased salinity discourages the water from freezing and allows for temperatures to drop below freezing point. The combination of the cold temperatures and high salinity = Antarctic bottom current a very dense body that can move along the ocean floor (read more about the thermohaline circulation)

**St. Lawrence Seaway** – Ships entering and exiting this water way have to pay close attention to the density of their cargo ships. The ocean water is denser and will allow the boat to have a greater buoyancy than the freshwater. For this reason they have to release ballast water upon entering the Seaway = zebra mussels...

### **Resources:**

#### **Currents, NOAA:**

Look at the links about Thermohaline Circulation and The Global Conveyor Belt.

Some good background information from NOAA:

[http://oceanservice.noaa.gov/education/tutorial\\_currents/05conveyor1.html](http://oceanservice.noaa.gov/education/tutorial_currents/05conveyor1.html)

#### **U-Boats, Density Currents, and the Strait of Gibraltar**

Great Social Studies link – how U boats used density currents during war.

<http://formontana.net/uboats.html>

#### **Strait of Gibraltar**

Mediterranean Inflow and outflow

[https://en.wikipedia.org/wiki/Strait\\_of\\_Gibraltar](https://en.wikipedia.org/wiki/Strait_of_Gibraltar)

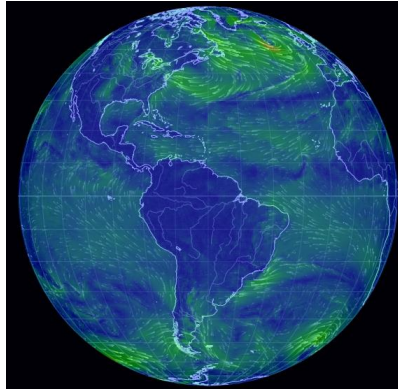
#### **Exploring the Earth, McDougal Little A Houghton Mifflin Company**

**Contains some nice activities for various topics.**

[https://www.classzone.com/books/earth\\_science/terc/navigation/home.cfm](https://www.classzone.com/books/earth_science/terc/navigation/home.cfm)



earth: [a global map of wind, weather, and ocean conditions](#)



<http://earth.nullschool.net/>

- This visualization of global weather conditions forecast by supercomputers is updated every three hours
- Ocean surface current estimates updated every five days
  - ocean surface temperatures and anomaly from daily average (1981-2011) updated daily
  - ocean waves updated every three hours

**Wind** | wind speed at specified height

**Temp** | temperature at specified height

**TPW** ([Total Precipitable Water](#)) | total amount of water in a column of air stretching from ground to space

**TCW** (Total Cloud Water) | total amount of water in clouds in a column of air from ground to space

**MSLP** ([Mean Sea Level Pressure](#)) | air pressure reduced to sea level

**MI** (Misery Index) | perceived air temperature combined [heat index](#) and [wind chill](#)

**SST** (**Sea Surface Temp**) | temperature of the ocean surface

**SSTA** (**Sea Surface Temp Anomaly**) | difference in ocean temperature from daily average during years 1981-2011

**Peak Wave Period** | [period](#) of most energetic waves, whether swells or wind generated

**HTSGW** ([Significant Wave Height](#)) | roughly equal to mean wave height as estimated by a "trained observer"

**COsc** (CO Surface Concentration) | the fraction of [carbon monoxide](#) present in air at the earth's surface

**SO<sub>2</sub>sm** (Sulfur Dioxide Surface Mass) | amount of [sulfur dioxide](#) in the air near the earth's surface

**DUext** (Dust Extinction) | the [aerosol optical thickness](#) (AOT) of light at 550 nm due to [dust](#)

**SO<sub>4</sub>ext** (Sulfate Extinction) | the [aerosol optical thickness](#) (AOT) of light at 550 nm due to [sulfate](#) about ocean waves

**Significant Wave Height** is the average height of the highest 1/3 of waves at a particular point in the ocean. There's a [great writeup here](#) describing what this means.

**Peak Wave Period** is the (inverse) frequency of the most energetic waves passing through a particular point, whether wind generated or swells. Certainly, there are many more groups of waves moving through an area, each in different directions, but trying to show them all rapidly becomes complex. Instead, we show the one wave group contributing the most energy. This has the effect, though, of creating "boundaries" between regions of ocean where the #1 wave group suddenly switches to second place. Often these boundaries represent swell fronts, but other times they are just artifacts of the ranking mechanism.

## about aerosols and extinction

An [aerosol](#) is air containing particles. Common particles are dust, smoke, soot, and water droplets (clouds). These particles affect sunlight primarily through absorption and scattering, which combine to reduce the amount of light reaching the ground. This loss of light as it passes through the atmosphere is called [extinction](#).

One common measure of extinction is [aerosol optical thickness](#) (AOT), which is (the log of) the ratio between the power of incoming light and the power of transmitted light. This helps us understand how "thick" the air is with particulates.

## Additional information about site and other helpful links

Weather Data | GFS (Global Forecast System) [NCEP / National Weather Service / NOAA](#)

Ocean Currents Data | OSCAR [Earth & Space Research](#)

Sea Surface Temperature | Real Time Global SST [MMAB / EMC / NCEP](#)

Waves | WAVEWATCH III [MMAB / EMC / NCEP](#)

Aerosols and Chemistry | GEOS-5 (Goddard Earth Observing System) [GMAO / NASA](#)

GRIB/NetCDF Decoder | [UCAR/Unidata THREDDS](#)

Geographic Data | [Natural Earth](#)

Hosting | [CloudFlare](#), [Amazon S3](#)

Font | [M+ FONTS](#), [Mono Social Icons Font](#)

Color Scales | [chroma.js](#) [ColorBrewer2.org](#) [Kindlmann Linear Luminance](#) [MYCARTA](#)  
[Dave Green's cubehelix](#)

Waterman Butterfly | [watermanpolyhedron.com](#)

Earlier Work | [Tokyo Wind Map](#)

Inspiration | [HINT.FM wind map](#) atmospheric pressure corresponds roughly to altitude  
several pressure layers are meteorologically interesting they show data assuming the earth is completely smooth

note: 1 hectopascal (hPa)  $\equiv$  1 millibar (mb)

1000 hPa | ~100 m, near sea level conditions

850 hPa | ~1,500 m, [planetary boundary](#), low

700 hPa | ~3,500 m, planetary boundary, high

500 hPa | ~5,000 m, [vorticity](#)

250 hPa | ~10,500 m, [jet stream](#)

70 hPa | ~17,500 m, [stratosphere](#)

10 hPa | ~26,500 m, even more stratosphere

The "Surface" layer represents conditions at ground or water level this layer follows the contours of mountains, valleys, etc.

Overlays show another dimension of data using color some overlays are valid at a specific height while others are valid for the entire thickness of the atmosphere

