# All About Wind

*Meteorologist Alexandra Holley*



# *What Even Is Wind?*

- Simply put, **wind is air in motion.**

- We cannot see the air, but we can measure its motion by the force it applies on objects like anemometers and wind socks.

- When we talk about wind, we usually mean the **horizontal component** instead of the **vertical component**. That's because the vertical component is usually very small (except in the updraft of a thunderstorm).



# *Okay, But Why Should We Care?*

- Wind is driven by air pressure. More specifically, the change in air pressure over a distance.

- Generally speaking, If the air pressure changes RAPIDLY over a SHORT distance, the wind will be FAST.

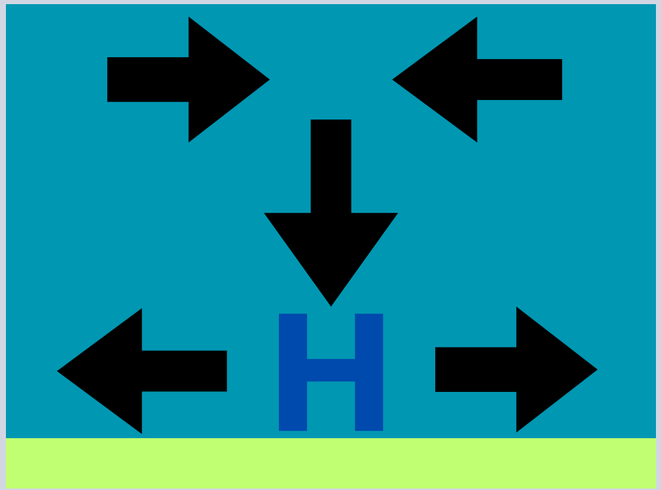
- If the air pressure is lazily changing over a longer distance, the wind will be less likely to send the little girl in the GIF into oblivion.

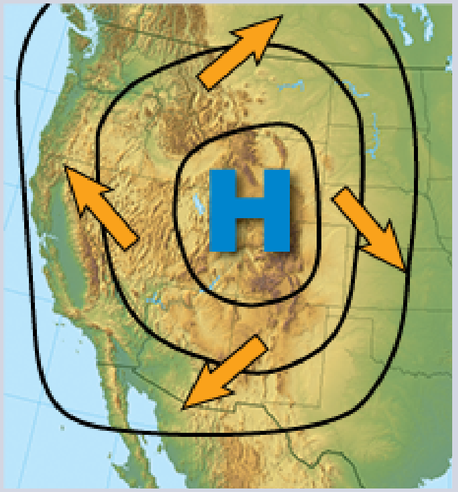


# *About Air Pressure*

- In Meteorology, we define air pressure as the force exerted upon us by the atmosphere above.

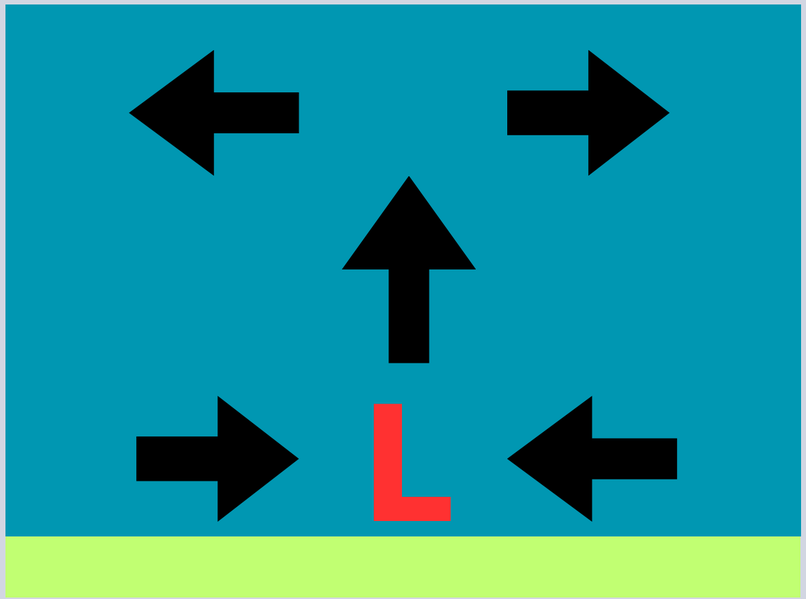
- High pressure (usually denoted on maps as **H**) is a region where the air pressure at the surface is greater than its surrounding environment.
  - Winds around high pressure systems move clockwise
  - Winds in high pressure are sinking (also called subsidence).
  - Subsidence results in sunny and warm weather over the area affected, generally.

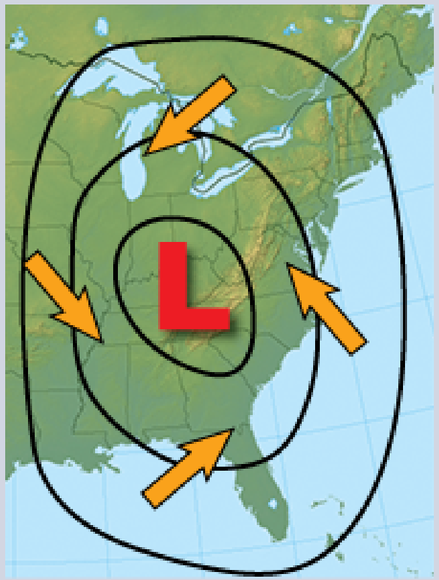


# *About Air Pressure*

- Low pressure (usually denoted on maps as **L**) is a region where the air pressure at the surface is lower than its surrounding environment.
  - Winds around low pressure systems move counter-clockwise
  - Winds in high pressure are rising (also called uplift).
  - Uplifting results in cloudy, even rainy or stormy conditions.



# *It's All About ✨Balance✨*

- One thing about meteorology: weather is always the result of the atmosphere trying to achieve equilibrium.

- The atmosphere doesn't like when the pressure is too high over there, the temperature is too hot over yonder, etc. So weather is the result of it trying to be balanced.

- Wind is air trying to achieve equilibrium by balancing out the atmospheric pressure. In comes...The Pressure Gradient Force (PGF).
  - Pressure Gradient Force (PGF) is the force that tries to equalize pressure differences. This is the force that causes high pressure to push air toward low pressure. Thus, in a perfect world, air would flow from high to low pressure if the pressure gradient force was the only force acting on it.
  - Wind is a **direct result** of the PGF.



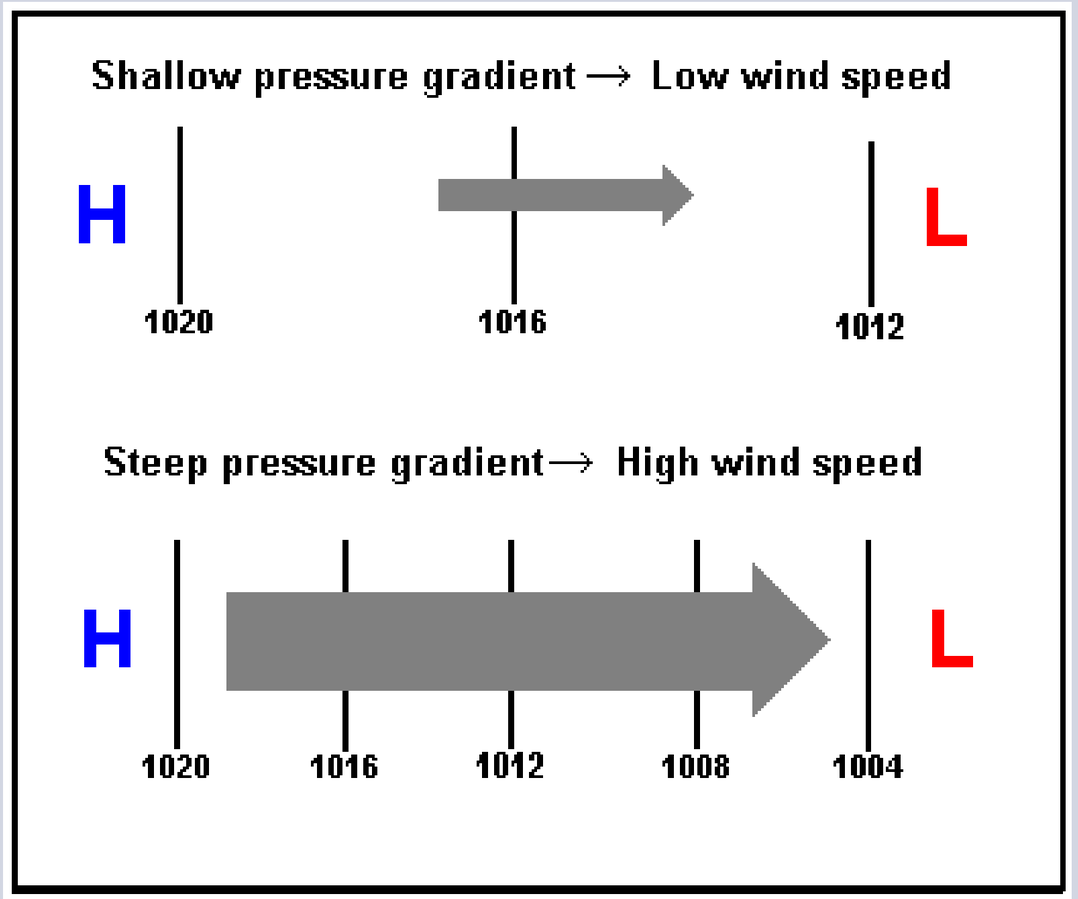
# Under Pressure (Gradient Force)

- If the air pressure is lowering slowly over a distance (shallow pressure gradient), then the PGF is low and that means the winds will be lower.

- If air pressure is lowering fast over the same distance (steep pressure gradient), then the PGF will be greater and result in higher wind speeds.

- Seems simple...right?

- But PGF is not the only force that acts on air, there are other forces we have to account for when talking about wind.



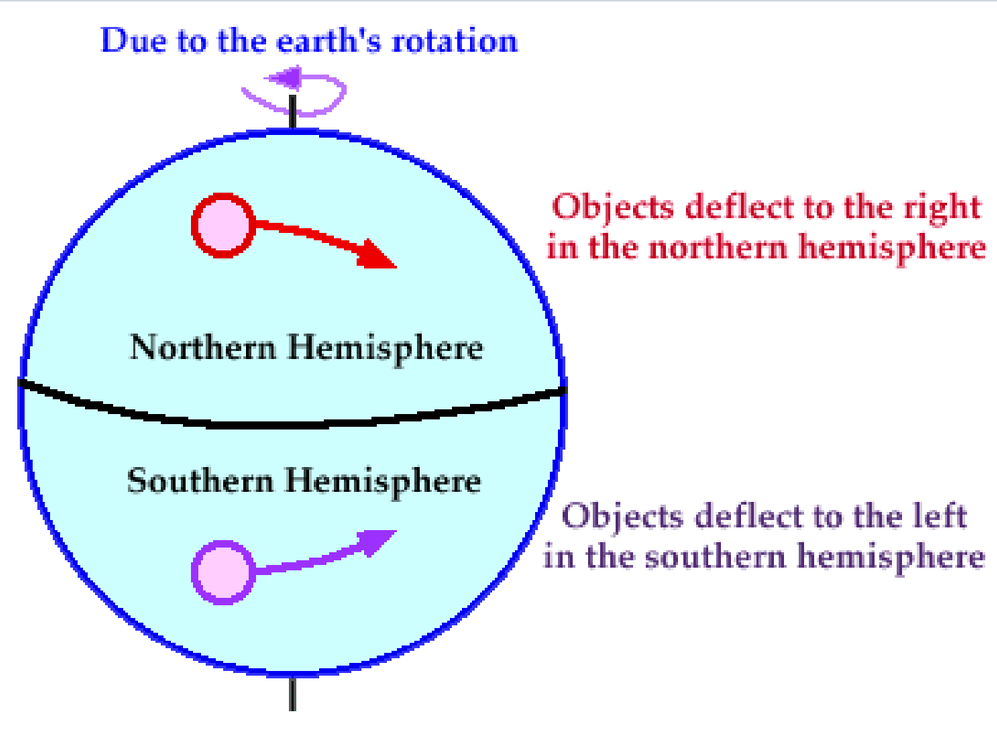

$$PGF = -\frac{1}{\rho}\left(\frac{\Delta P}{\Delta x}\right)$$

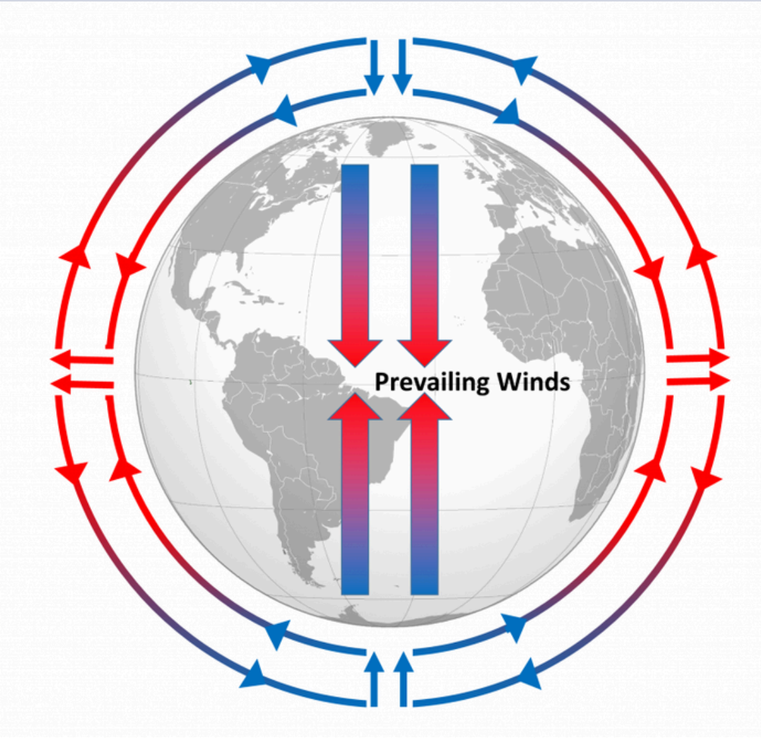
# Coriolis “Force”

- The Coriolis Force is an effect that causes objects (including air) to turn right in the Northern Hemisphere, and left in the Southern Hemisphere.

- **Fun fact: it’s not an actual force!**

- It’s a pretty weird phenomenon, but the cause is simple: **Different parts of the Earth move at different speeds. The equator spins faster than the poles!**



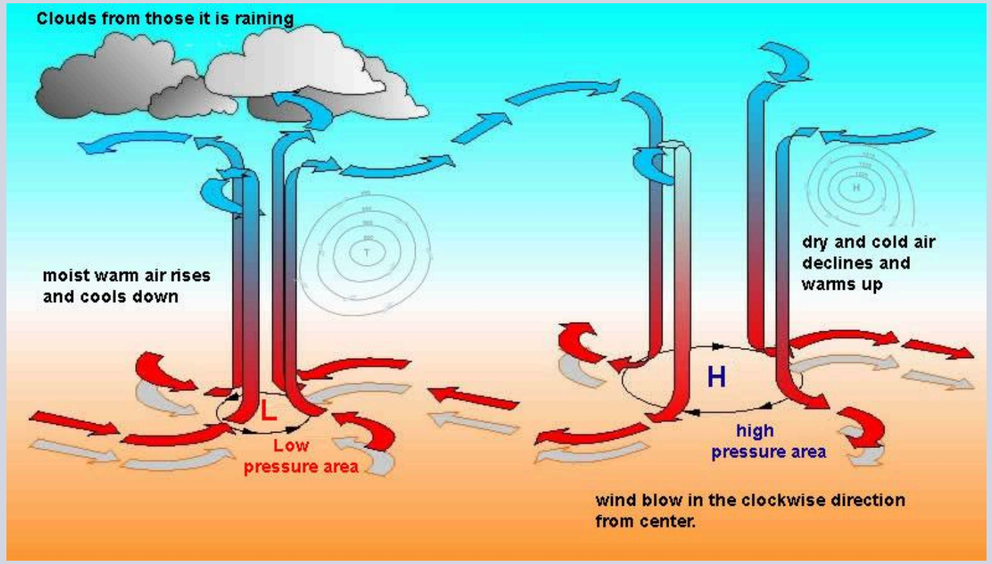
# Coriolis “Force”

A good way to see this is look up flight paths from Europe to America. **The Coriolis Effect makes things (like planes or currents of air) traveling long distances around Earth appear to move at a curve as opposed to a straight line.**



# It’s Not Always Smooth

- One more force we have to account for with wind is **friction.**
  - Friction is the mechanical resistive force of one object on another object's relative movement when in contact with the first object.
- Two types of friction occur in the atmosphere: One is **molecular friction** (friction between individual air molecules (called **viscosity**)) and **friction between two surfaces** (**i.e. friction between air and land**).
- Friction between two surfaces is why Hurricanes weaken and slow down as they make landfall on the coast.
- Not only does friction decrease the wind speed, it also changes the direction of the wind.
  - **Friction causes the wind to converge** (**flow towards**) **towards Low Pressure and diverge** (**flow away**) **from High Pressure.**



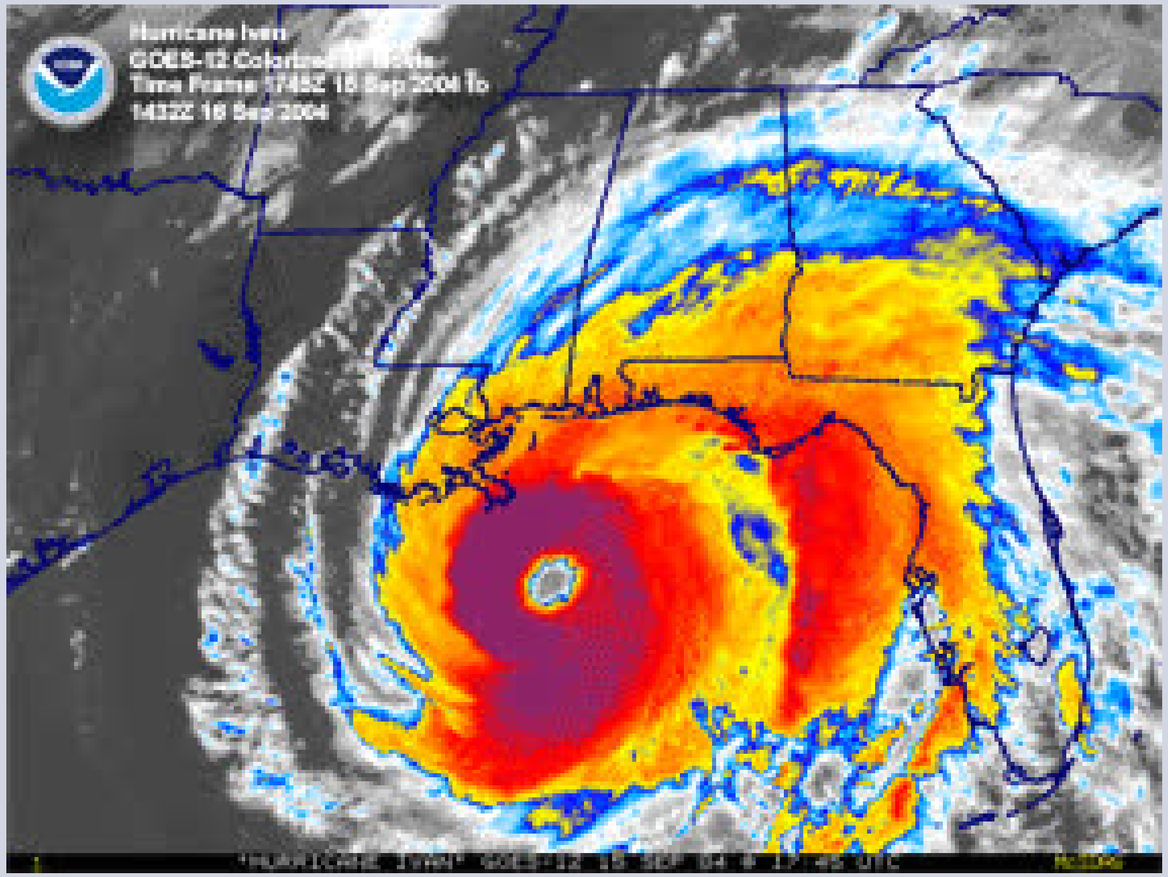
# *TL;DR...*

**Wind generally moves from high pressure to low pressure because it is started by the Pressure Gradient Force. Wind Speed is dictated by this force. Its direction is then dictated by friction and the Coriolis Effect.**



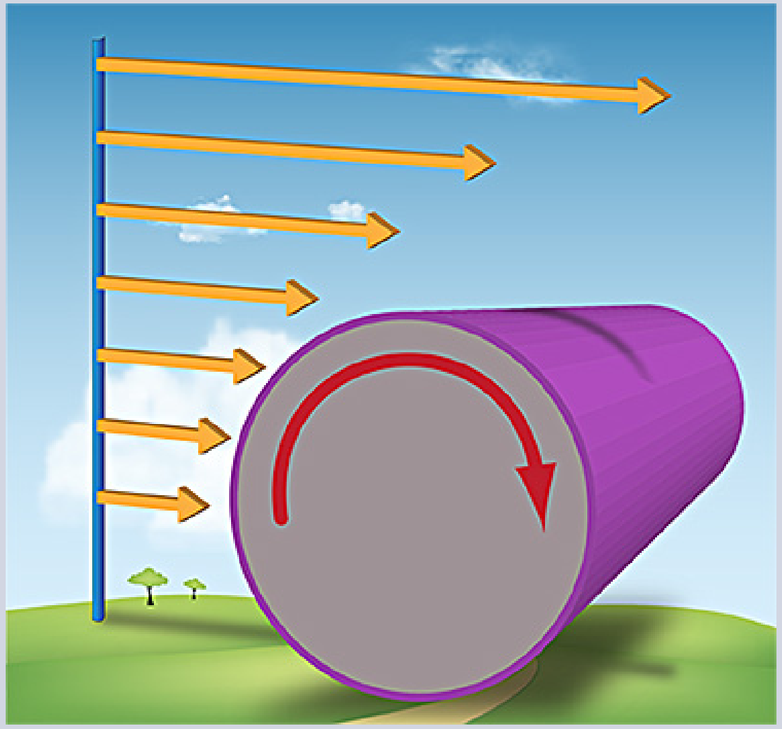
# Severe Weather & Wind

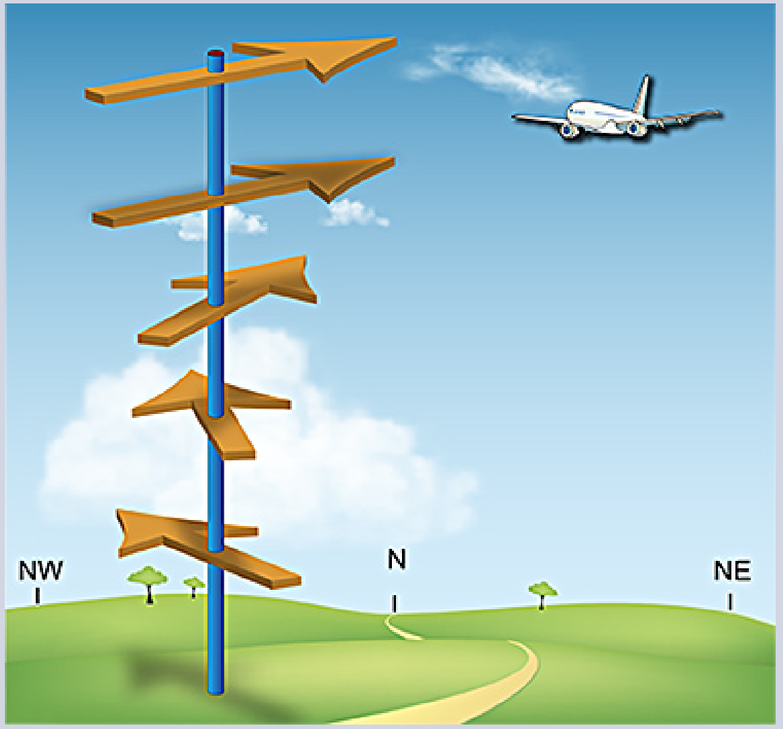


# *Severe Weather & Wind*

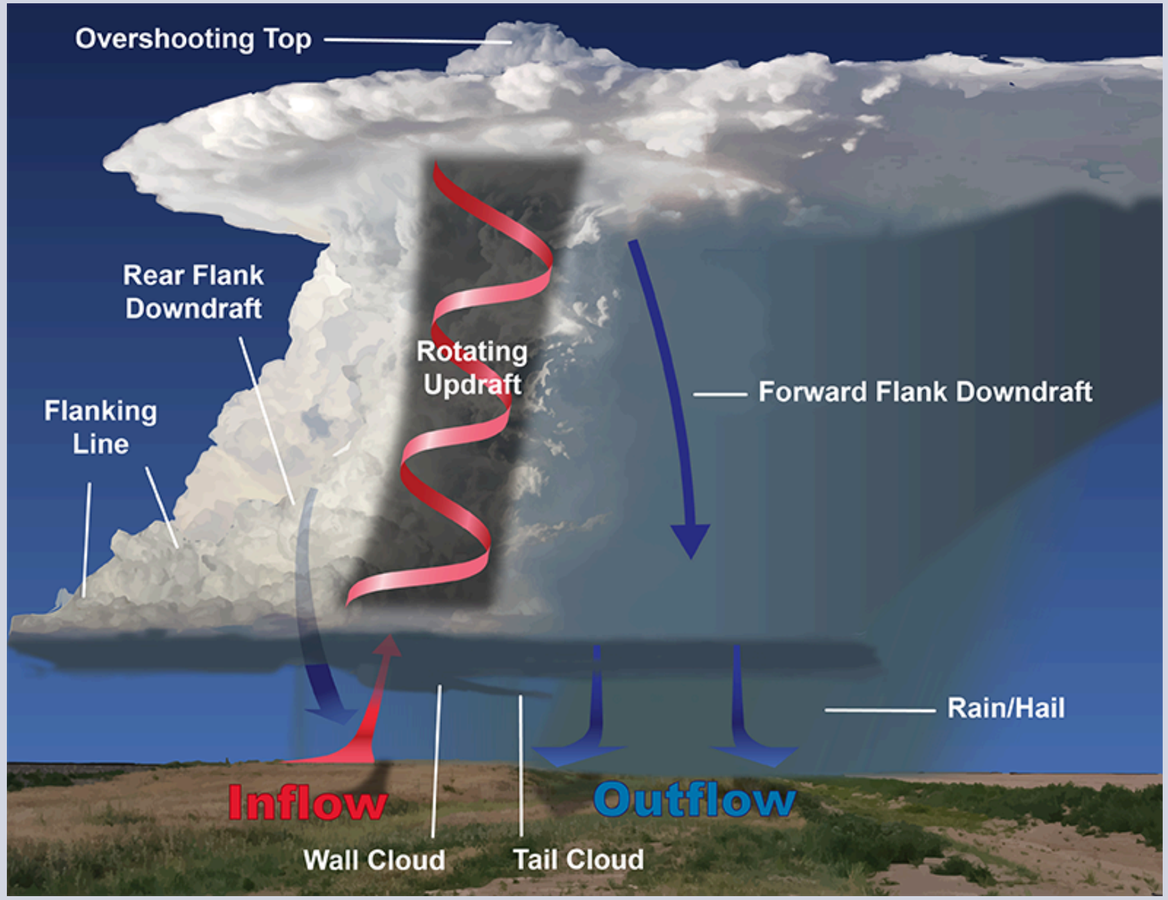
- Wind is necessary for severe weather, more specifically wind shear.
- There are two types of wind shear:
  - **Speed Shear** is when wind speed increases with height.
  - **Directional Shear** is when wind direction changes with height.
- Both Speed and Directional Shear are necessary for supercell formation!





# Severe Weather & Wind

- Working together, speed shear and directional shear induce a rolling motion to the lower atmosphere. When an updraft is initiated, the rising air lifts this rolling tube into a vertical position.
- Wind shear helps the updraft to tilt itself away from the downdraft, allowing it to become stronger and the storm to become supercellular.
- Without this, the downdraft would overwhelm the updraft, and the storm would choke itself.

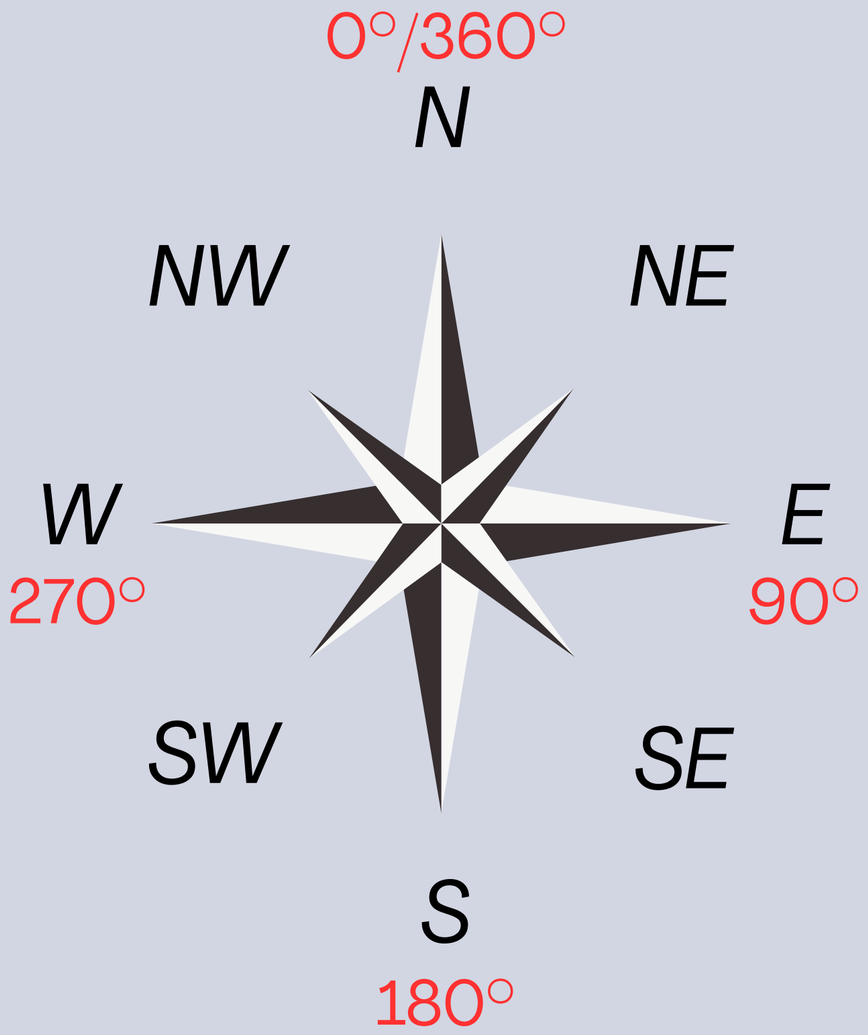


# *How Do Meteorologists Measure The Wind?*



# *Wind Speed and Direction*

- Wind Speed is the rate at which the air is moving horizontally past a point in the atmosphere.
    - Wind speeds can either be sustained or gusts. Gusts are sporadic and usually stronger than the sustained winds.
- Wind direction is the direction that the air is coming from.
    - **It is always described as the direction the air is COMING FROM, not blowing towards.**
    - Example: A Northerly wind is coming from the north, not blowing to the north.
- **Wind direction is measured in degrees**, like a compass. **Wind speed is measured in knots** that we convert to MPH.



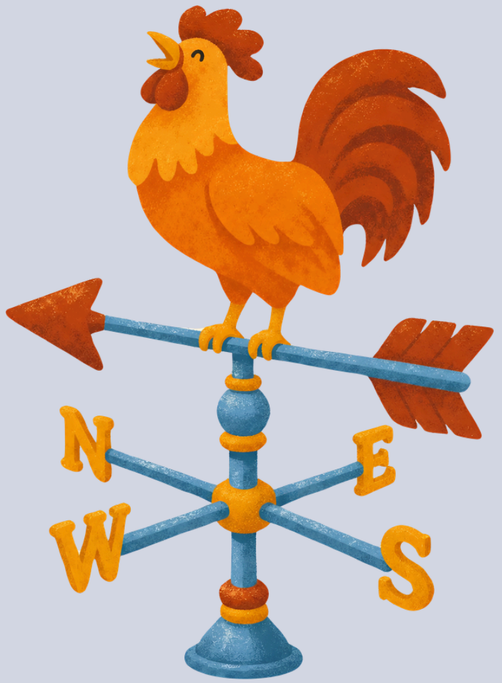
# *Tools of The Trade*

## Wind Vane

- A wind vane measures the direction the wind is blowing.

- It works because the back end has a bigger surface area than the front, so it is caught by the wind, and points the arrow directly into the wind.

- Nowadays, it is typically seen more as a decoration than a scientific instrument. However, you still see them in rural areas and with personal weather stations.






# *Tools of The Trade*

## Anemometer

- An Anemometer is a device that measures wind speed
  - **Cup Anemometer:** Commonly seen with personal weather stations. Cheap, and effective, unless there is freezing rain.
  - **Ultrasonic Anemometers:** What the NWS and FAA use with our Automated Surface Observation Systems (ASOS). Uses disturbances and sound waves to calculate wind speed. It has no moving parts and relies on sonic pulse technology to measure both wind speed and direction.
- Anemometers are more important than wind vanes because wind speed directly impacts operations for aviation, marine, trucking, and other industries.



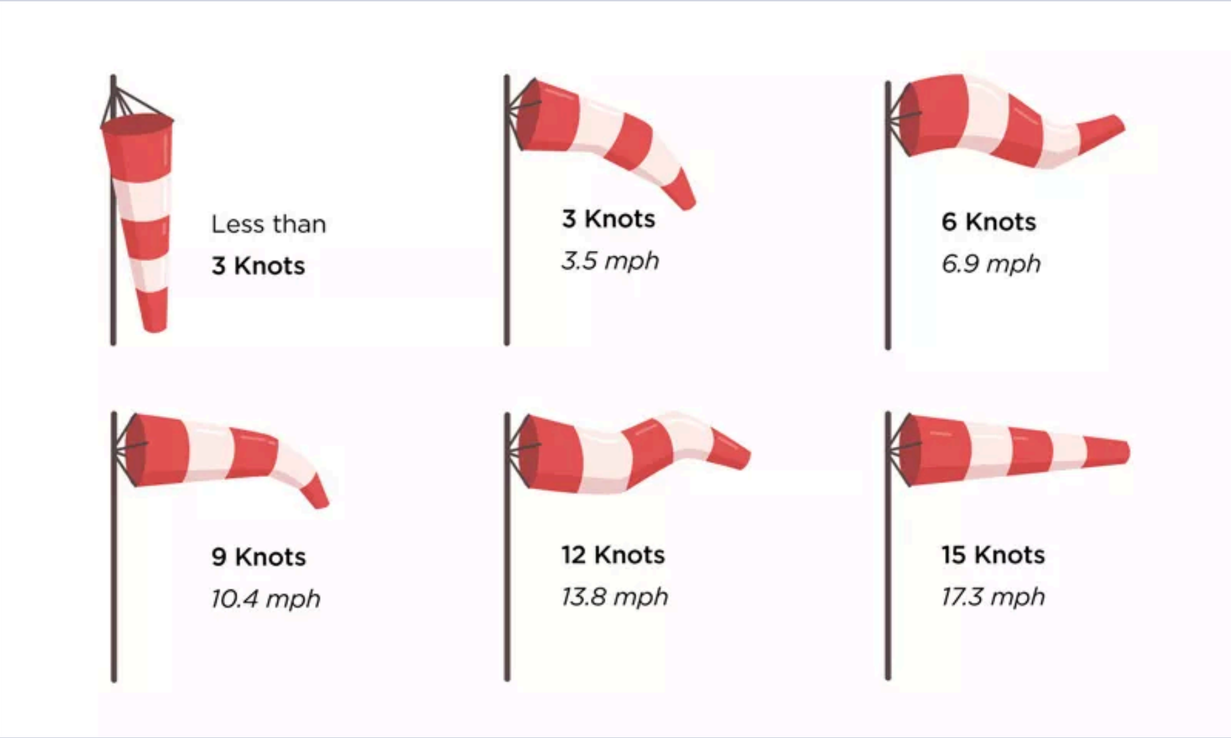


# *(BONUS!) Tools of The Trade*

## Wind Sock

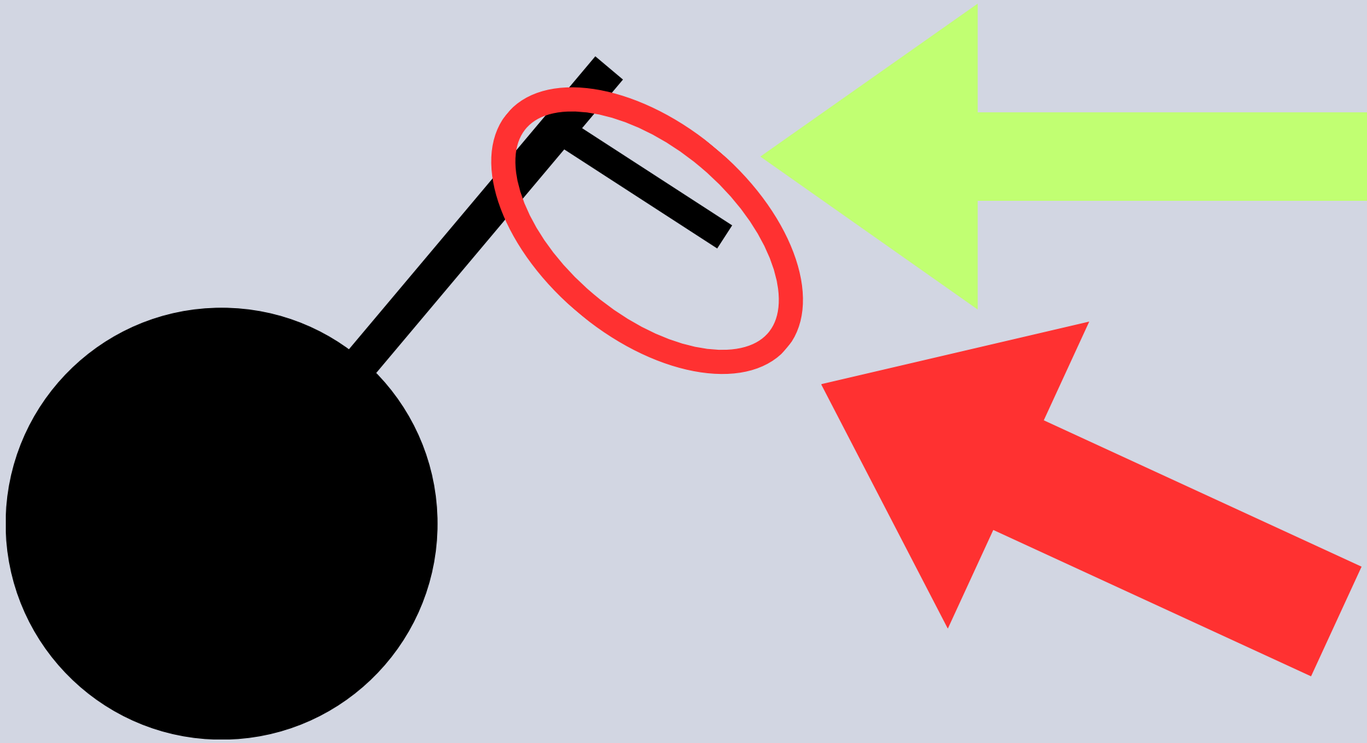
- Wind socks are commonly used at airports to measure wind speed and direction
- While not exact, they provide a visual representation of wind direction and approximate wind speed for pilots.





# *How To Read A Surface Plot*

You can get a lot of information from surface plots, but let's focus on the wind components!

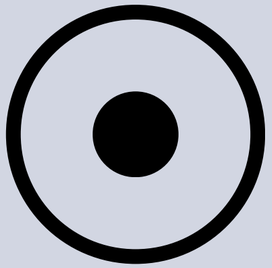


The long line extending from the circle shows what direction the wind is blowing from.

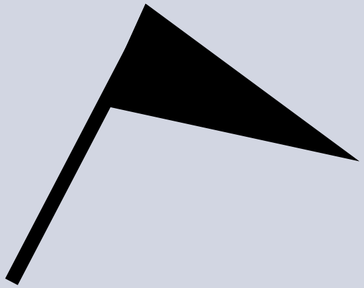
The barb on the long line tells you the wind speed

# How To Read A Surface Plot

The general mechanics for reading the wind speed on a surface plot is fairly simple. Wind speeds are plotted by 5 knot increments.



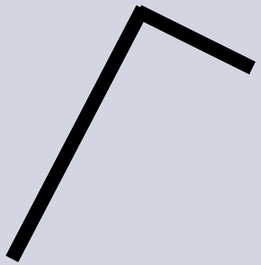
No barb? That means winds are Calm



A flag is 50 knots



A half barb is 5 knots



A full barb is 10 knots



# Questions?

Meteorologist Alexandra Holley

alexandra.holley@noaa.gov

US National Weather Service - Nashville, Tennessee

@NWSNashville