Atmospheric Cells, Climate Change, and Arctic Blasts

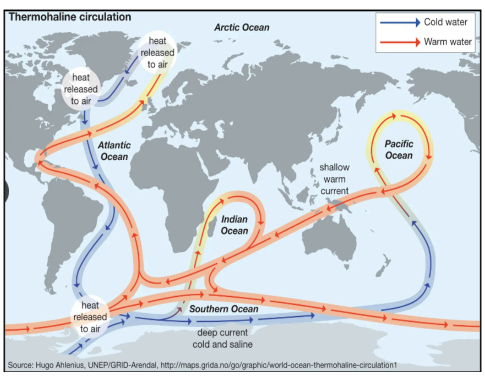
Last time **(CSSG-2.13)** we got a first glimpse of

The Big Three Energy Pumps

The **Deep Ocean Conveyor Belt**, which is driven by the differing gravity pulls on the water as it becomes more or less dense from higher/lower temperatures and higher/lower salt contents.

The big pumps (the **Overturning Circulations**) are near the Poles, where the temperatures drastically fall and salinity drastically increases, causing the water mass to plunge down from the surface to the bottom.

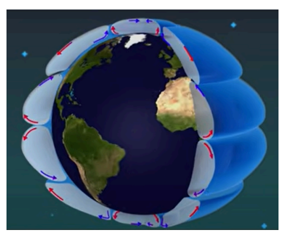
This deep current moves **heat** from the equator towards the poles, brings **nutrients** from the deep ocean to the surface (feeding abundant ocean surface life), brings O_2 to the deeps (allowing deep life) and sucks CO_2 from the atmosphere (delaying the impacts to us on the surface).

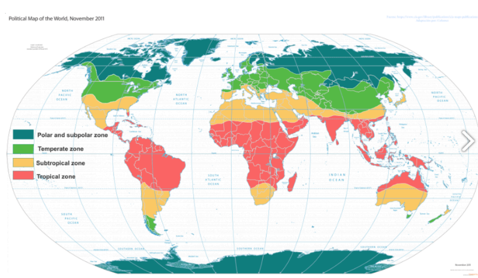


The **Atmospheric Circulation Cells**, which are driven by the difference in temperatures between the Equator and Poles. Air near the Poles is very cold and contracts; near the Equator, it greatly expands upward. This provides an effective downhill slide for air towards the Poles.

On the way, cells form in bands around the Earth as hot, moist air rises to colder altitudes - causing heavy rains in the tropics and in the subpolar zone. In other latitudes, where cold, dry air descends to replace the rising hot air, more arid regions form.

These cells move heat from the equator towards the poles, **establishing climate bands around the earth**.

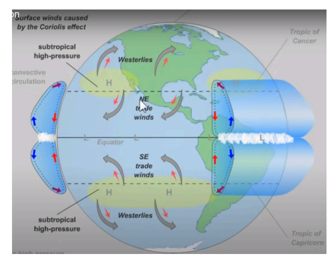


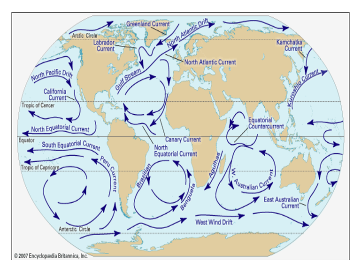


The **Surface Winds and the Ocean Surface Currents which they propel** are driven by the Atmospheric Circulation Cells - with the added impact of the **Rotation of the Earth**..

These new sideways and circulatory actions (as contrasted to the North/South flows of the atmospheric circulation cells), are a result of the **Coriolis Effect**, which is a result of the Earth's rotation**.**

These winds and surface currents move energy into the local ecosystems, climates, and weather.





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Approximate "Cheat Sheet":

1 meter → 3 feet **1 degree Celsius (^{0}C)** → 2 degree Fahrenheit (^{0}F)
ppm = parts per million CO_2 = Carbon Dioxide
1 tonne = 1000 kilograms = 2205 pounds **1 gigatonne (1 Gt)** = 1 billion tonnes
1 trillion tonnes (1Tt) = 1000 gigatons

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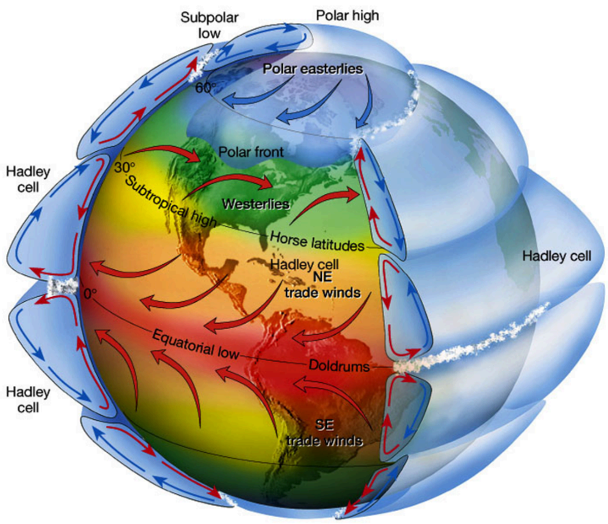
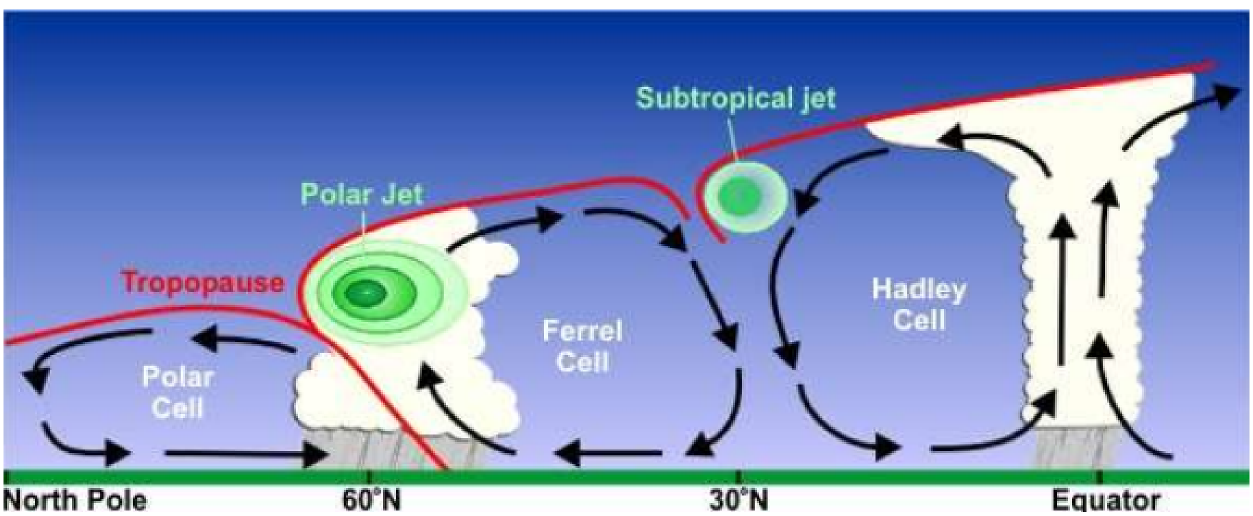
This Study's focus is on the Atmospheric Cells, and one of the dominant impacts of Climate Change - **ARCTIC BLASTS**. Here's another depiction of the Atmospheric Cells:



https://eos.org/science-updates/how-do-climate-variations-affect-the-width-of-the-tropics

Let's take a closer look at the atmospheric cells, in the graphic below **Two new features** are jumping out, compared to last week's discussion:

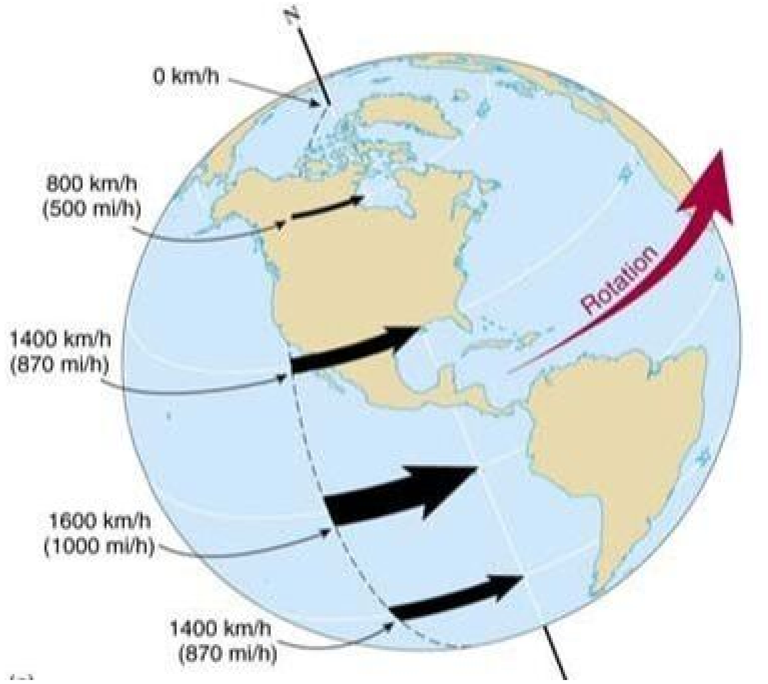
1. The **strong downhill tilt** towards the poles at the top of the Troposphere (the changing region of our surface weather). This downhill tilt is caused by the large temperature difference between the equator and the Poles. Heat drives the top of the Troposphere way up at the Equator; Cold constricts the atmosphere to low altitudes at the Poles.
2. The **Jet Streams** forming at the North edges of the cells.

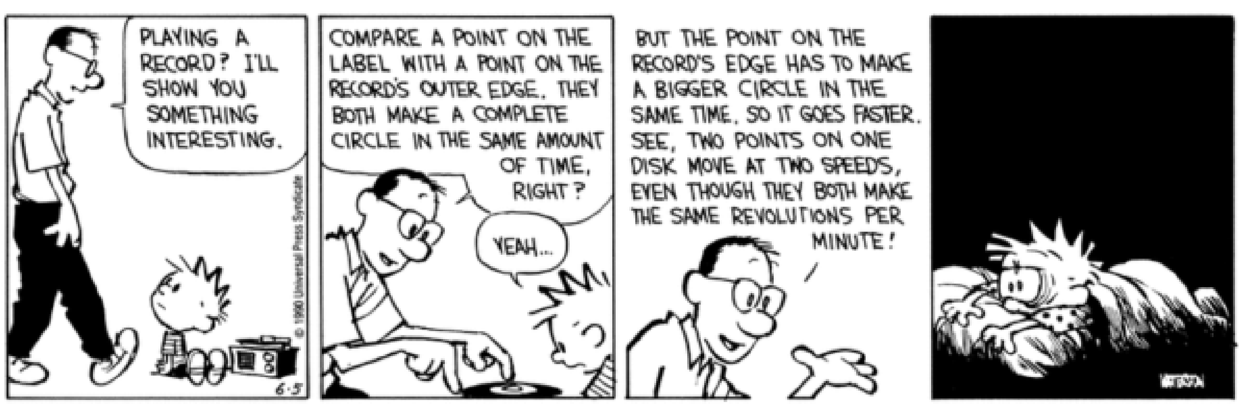


https://geophile.net/Lessons/atmosphere/atm_circulation_04.html

A quick introduction to the Coriolis Effect (it will come up again in later studies of surface winds and surface ocean currents).

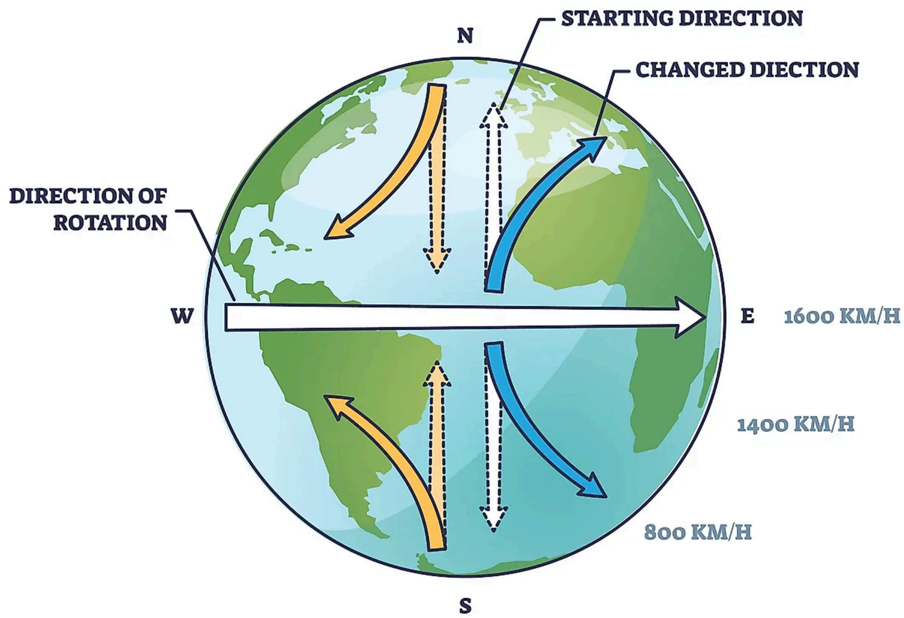
First, just notice that the earth rotates and that to get around the circle, air at the equator has to be going a lot faster than air near the poles.



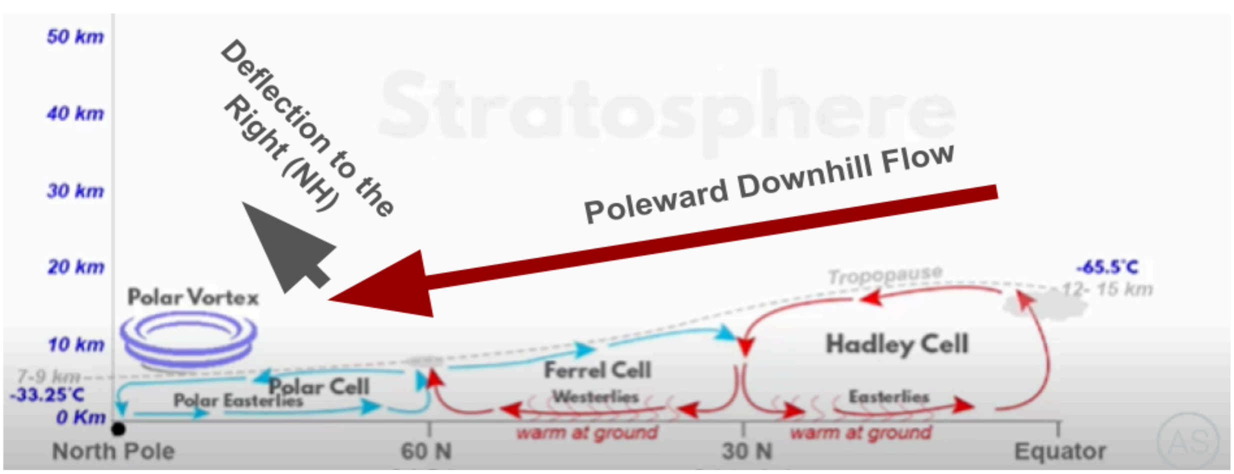


This implies that air flowing from the equator towards the poles will be **deflected to the Right (in the Northern Hemisphere; the opposite is true in the SH).** This simply reflects that it's got a faster rotational speed, since it started at the equator.

One other point: the faster it is going North (in this case) the faster it picks up sideways speed.

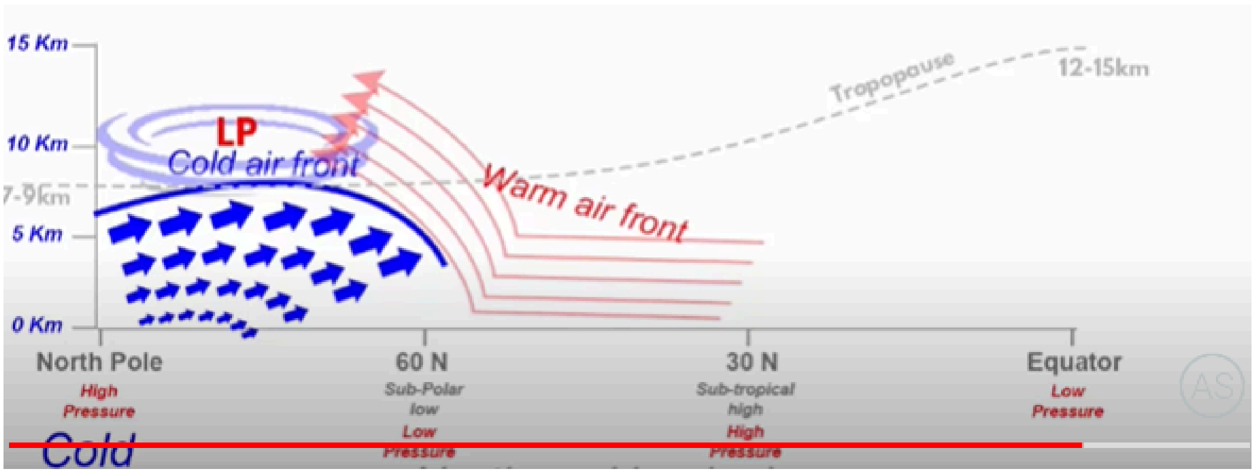


The **POLAR VORTEX** forms in the STRATOSPHERE (the quiet layer above our tropospheric weather) as a result (as best as I can tell from my early study) of the strong, downhill flow directly from the equator towards the Poles. The Rightward Deflection from all around the globe forms into the **POLAR VORTEX**. This vortex, when strong, restricts the cold, polar air from moving Southward.

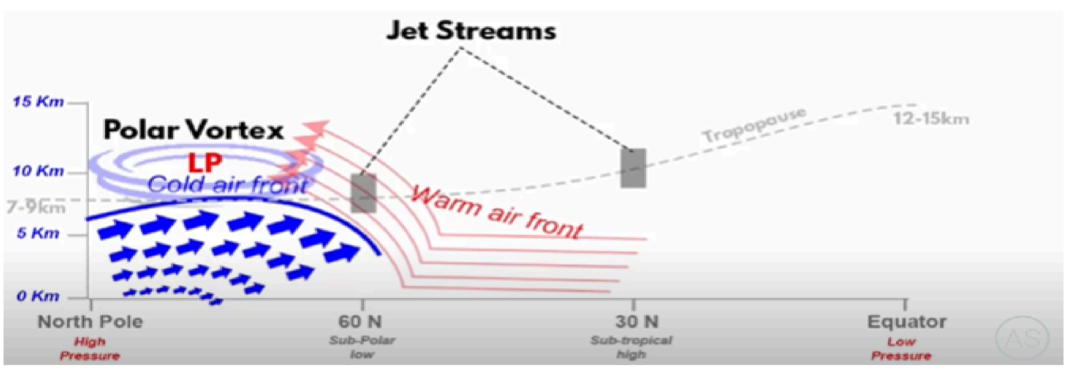


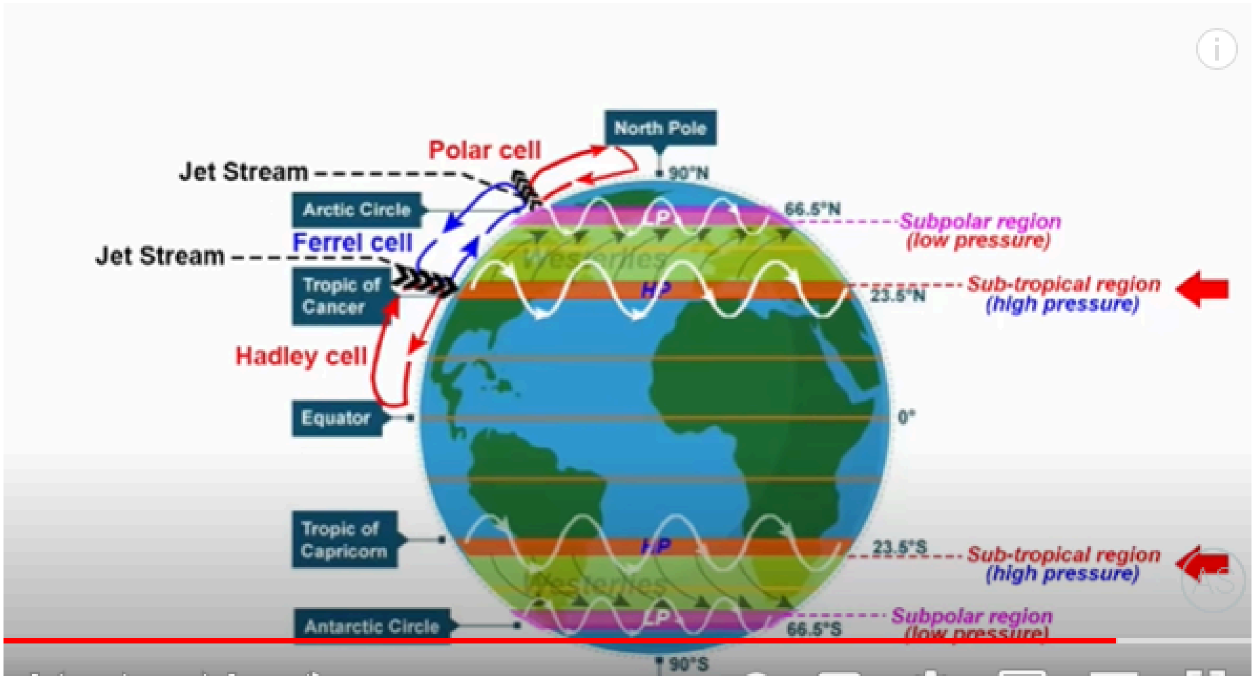
In similar fashion, but down a little into the Troposphere, the Northern-going segments of the Hadley and Ferrel cells dominate the flows at the Tropopause (where the troposphere and stratosphere meet.

Here's how the northern edge of the Ferrel cell generally flows:

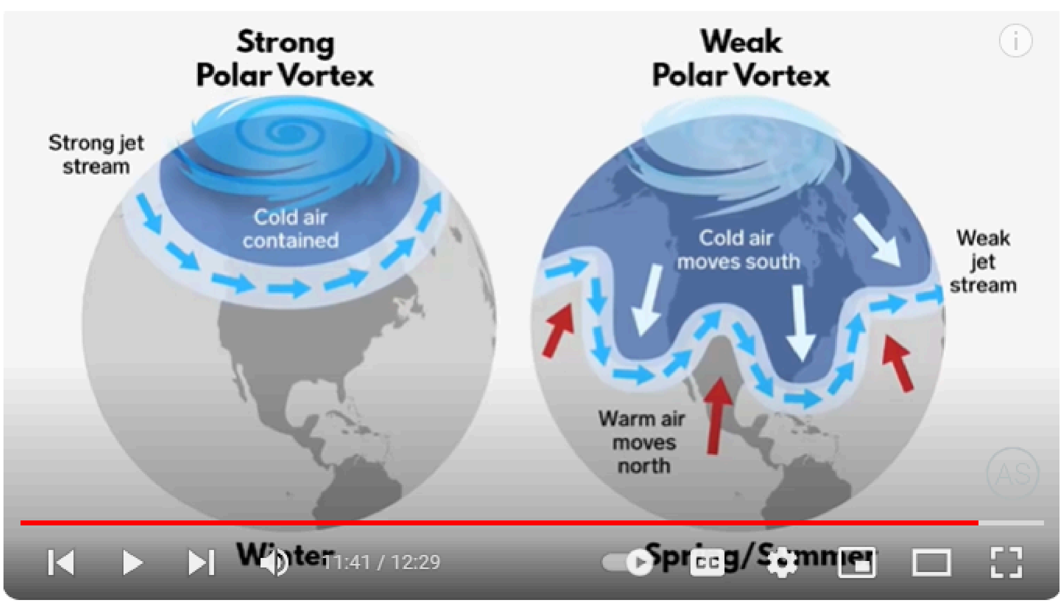


These strong tropospheric winds, again moving North in the NH, are deflected to the Right - this time forming the JET STREAMS.





Now for the FUN PART! If the Polar Jet Stream and the Polar Vortex are both strong, cold air is mostly constrained. This generally happens in the winter, because the temperature difference between the Poles and the Equator is at its maximum. This maximizes the velocity of Northern-going winds which in turn maximizes their deflections to the Right. These conditions make the least-wavy jet stream.



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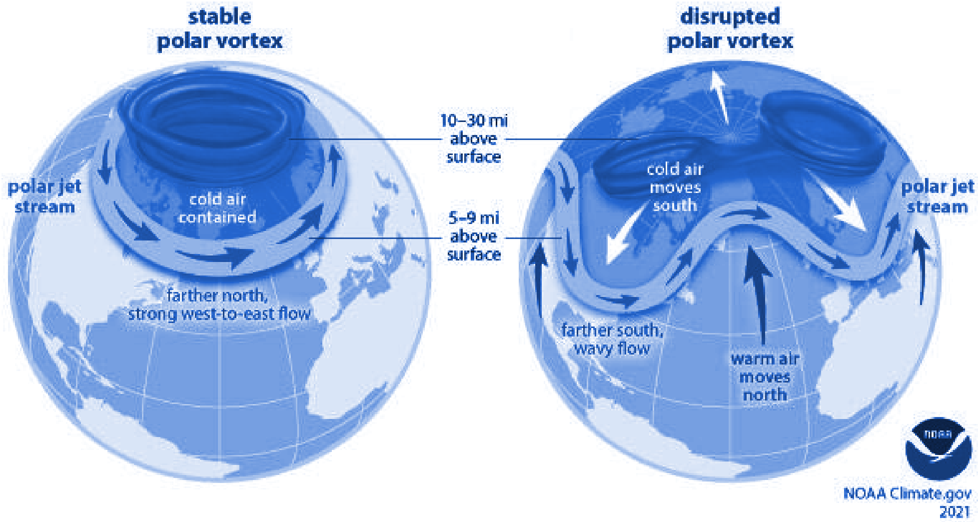
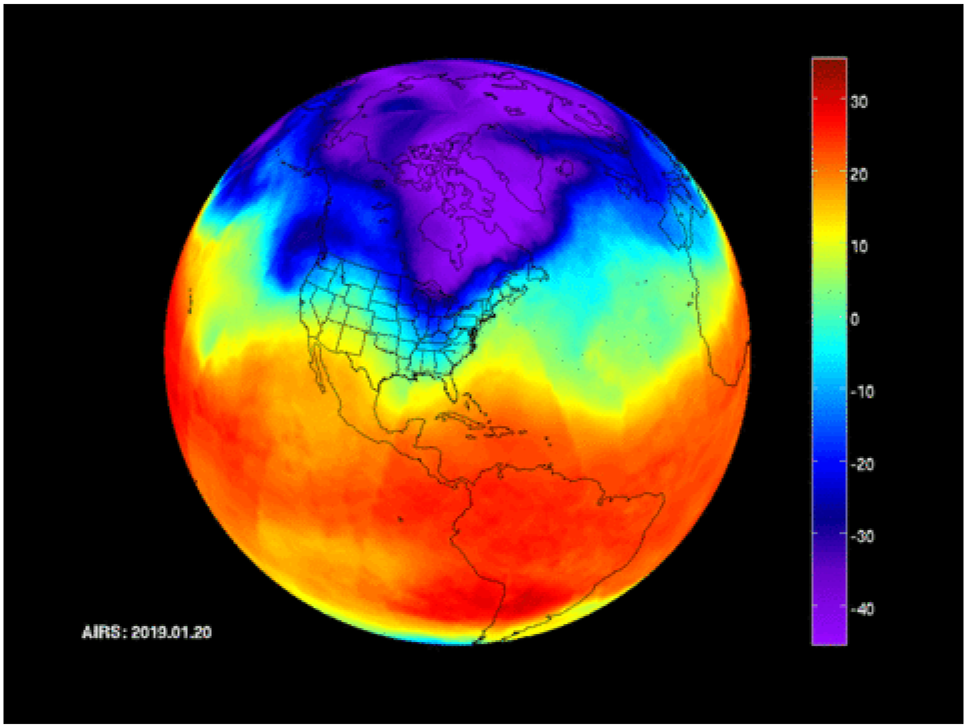
If the Northern-going winds are weaker, the stability is tripped up.



When the Arctic polar vortex is especially strong and stable (left globe), it encourages the polar jet stream, down in the troposphere, to shift northward. The coldest polar air stays in the Arctic. When the vortex weakens, shifts, or splits (right globe), the polar jet stream often becomes extremely wavy, allowing warm air to flood into the Arctic and polar air to sink down into the mid-latitudes. NOAA

From 1989 to 1998, there were no split vortex events in midwinter. But in recent decades these events have been happening more frequently. This animation shows the polar vortex splitting in 2009. (Image credit: Aditi Sheshadri)

NASA's Atmospheric Infrared Sounder instrument captured the tropospheric jet stream moving from Central Canada into the Midwestern United States from Jan. 20 through Jan. 29, 2019, bringing storms and cold Arctic air with it. (Image credit: NASA/JPL-Caltech AIRS Project)



The PUNCHLINE IS:

ONE of the many impacts of Climate Change on the Atmospheric Cells (and, therefore much of our Tropospheric weather), is the more frequent weakening of the Polar Vortices and the Jet Streams. These weakenings are a result of the Poles warming faster than the equator (it is warming at 4x the rate of the equator), which reduces downhill slope and, therefore, the strength of the Northern-going winds which reduces the velocity of the Polar Vortex and Jet Streams.

The results include **THE ARCTIC BLASTS** !

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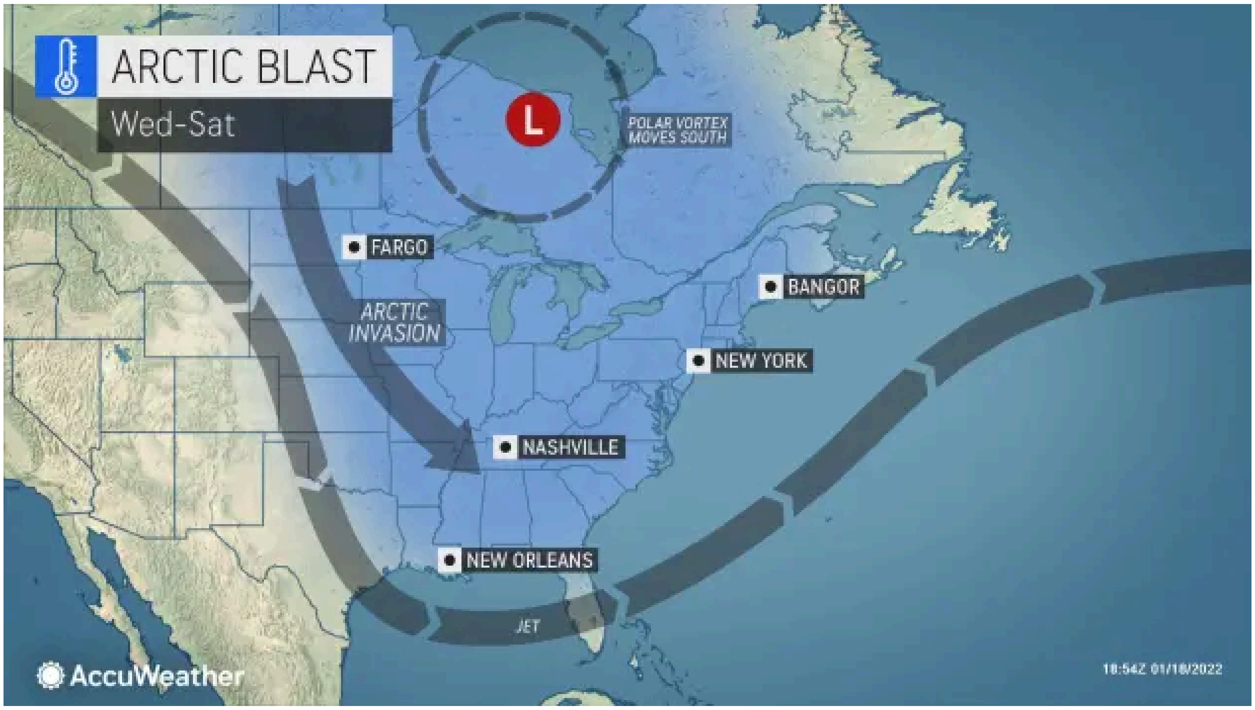

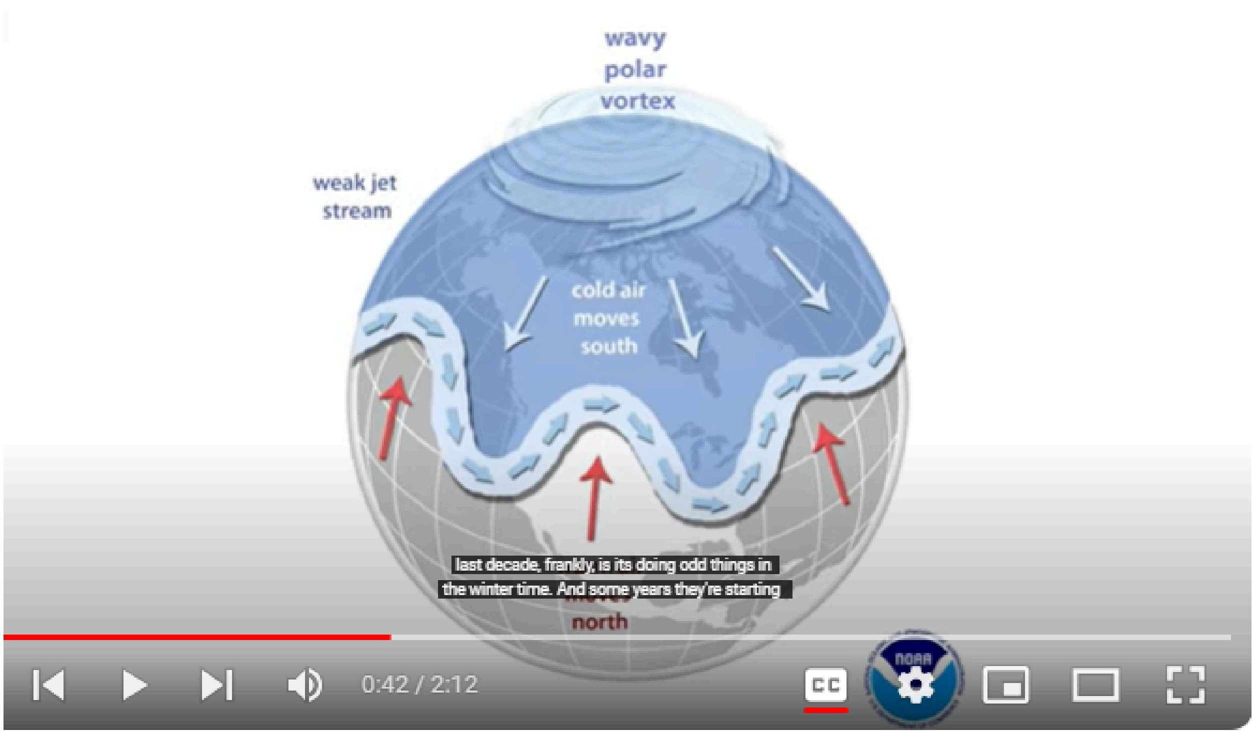

From another source:

How Is the Polar Vortex Affected by Climate Change?

While the polar vortex is well documented, its behavior has become more extreme as a result of climate change, according to Ullrich.

He explains: warming of the Earth has led to the loss of Arctic sea ice, transforming a highly reflective icy surface to a dark absorptive surface. The change is warming higher latitudes and reducing the temperature difference between the warmer mid-latitude and polar regions. This weakens and destabilizes the polar jet stream, causing it to dip into lower latitudes, bringing polar air farther south.

Ullrich expects future climate change to further weaken the polar jet stream, bringing rise to more extreme and unusual weather patterns. *https://www.ucdavis.edu/climate/definitions/what-is-the-polar-vortex#:~:text=A%20low%20pressure%20system%20creates,polar%20air%20out%20and%20away*.