Understanding the Need for Climate Resiliency:
How Does Gas in the Atmosphere Impact Weather?

Why would anyone believe that there is a change in climate?

Arenac Conservation District, 2025

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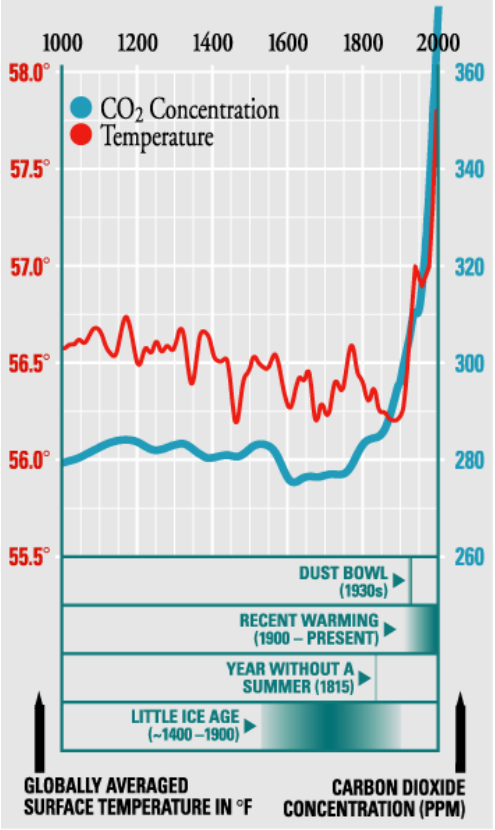
This is an explanation of the mechanics in physics and chemistry that shape what we understand about weather. **These are the fundamental concepts used to understand and predict <u>how changes in the proportion of gases in our atmosphere impact long-term weather patterns. (A.K.A, Climate)</u>**



Then, we introduce the concept of climate shifting, which is the reason that the Climate Resilient (Assisted Tree Range Expansion Project) is doing their work. This uses a strategy called "Climate-Analog Mapping" to identify what changes to expect, and helps us understand which species we can choose now that will be able to tolerate or capitalize on these changes.

Before we begin, we need to establish a common fact shared by everyone, which is that the amount of CO2 particles in the air has increased sharply in the last 200 or so years. Rising from 270ppm to over 400ppm. This is measured using a carbon dioxide meter. You can check the current concentration here
(https://www.co2.earth/daily-co2)

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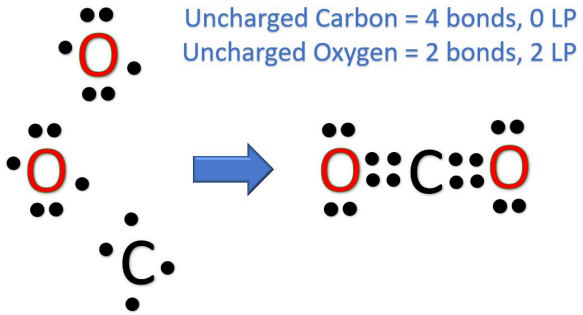
The Physics and Chemistry of it: Why do different molecules hold different amounts of energy?

The increased amount of CO2 molecules in the atmosphere traps heat because of something that happens in chemistry called polarity and chemical bonding. Higher temperature means higher energy, and energy is stored in the electron bonds between the atoms that make up a molecule.

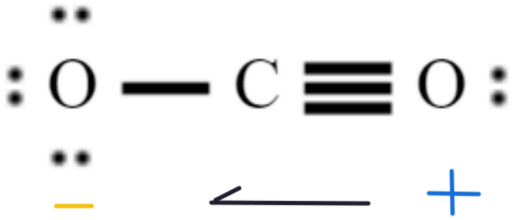
Different atoms hold different amounts of electrons (e-). Energy can pass freely between electrons (e-) across a molecule through their bond. So the distribution of energy across the molecule can change depending on the type of bond, the amount of bonds, the position of the (e-) around the atom, and the energy available around it.

Some atoms are bonded by 1 pair of (e-), others are able to tolerate 2 or 3 bonds like CO2. When there isn't a lot of energy available- stable molecules share (e-).



When there is more energy the pace of movement is increased leading to concentrations of (e-) around one side of the molecule which we call, Polarity. If there is too much energy the bonds between molecules can break when one atom takes up all of the available (e-).

A molecule with more bonds is harder to break, bonding flexibility allows it to tolerate the storage of more energy.



Because CO2 is able to manage the movement of energy across (e-) with single, double, or triple bonding when concentrations occur **AND** it has 2 portions (O=C=O) able to perform this rather than the 1 portion of a typical pair bonding of average atmospheric gases like N2, or O2 (N=N, O=O). It is able to tolerate a higher capacity for energy storage at any given time, so when there are more CO2 molecules in one space, there is also more energy in that space.

It's undisputed that the amount of CO2 in the atmosphere has risen over time.[1] The energy we have in our homes and cities comes from burning fuels rich with carbon. When carbon combusts it becomes gaseous. Interacting with the O2 and forming CO2. When we burn a lot of carbon, we create a lot of gaseous CO2 and all of that CO2 hanging around in the atmosphere soaks up energy from the sun and unlike N2 or O2 it does not break as easily.

[O2 breaks after 498KJ/mol of energy while co2 breaks after 1600KJ/mol of energy]

This increased amount of energy available in the atmosphere stored in the CO2 that hangs around leads to air masses moving more often, and colliding with greater force. What does this mean for our weather?

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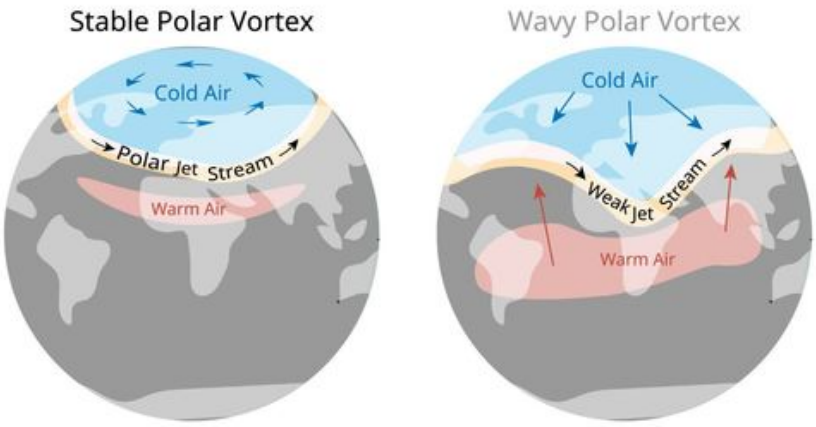
The Meteorology: Why does it matter that air masses move more often?

With more available energy in the atmosphere, the frequency of movement of air masses increases. (*Gas particles vibrate at a higher rate with more energy leading to more movement.)
One risk of this increased movement is more frequent collisions between the cold air mass of the north and the hot air mass of the south. The line of collision is what we call the jet stream, the force of the collision determines the intensity of the storm.

When air masses are lower energy, the resulting storms are lower energy and less intense. When the air masses move with high energy, the force of the impact between them is what creates intense and destructive storms. This is one consequence of more energy being stored in the gaseous molecules that make up the atmosphere. When there is excess energy available, volatility increases. This can destabilize the jet stream we rely on to provide us with consistent, manageable rainfall.

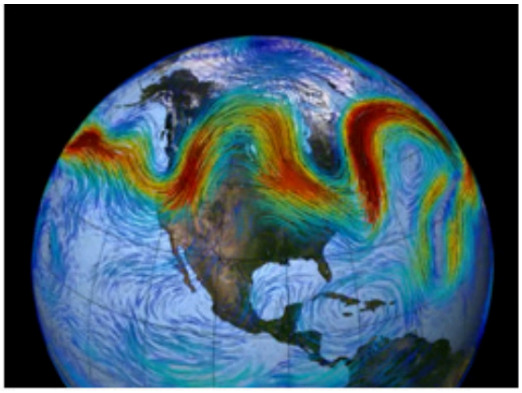
In a highly energetic atmosphere, the jetstream loses consistent shape leading to cold and hot portions being driven further north or south. It is inevitable that with more energy, there is more movement so in turn we are witnessing a change in the long term patterns of weather, (which we call climate).



The jet stream is no longer stable enough to contain the air masses in their respective places so they are beginning to fluctuate.

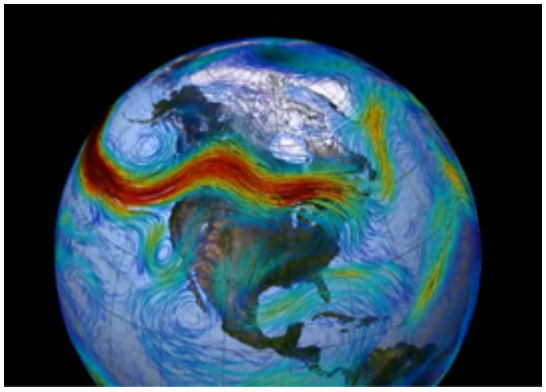
With both, more intense storms and the capacity of the southern and northern air masses to travel deeper, we are experiencing weather conditions that are different from what we have experienced in the past when there was less gaseous carbon in the atmosphere.

As a result we see things like this **[2a]**, a wobbly jet stream, more often.



[2a]Wobbly, Unstable Jet Stream

Rather than this **[2b]**, a stable jet stream and contained air masses. Which is what we have been used to and what we have tended to base our land management decisions on.



[2b]Contained, Stable jet stream

What does this change mean for us?

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Large air masses colliding with more force increases the intensity of storms, this can flood fields and towns damaging harvests and destroying property. (Michigan is particularly prone to increased flooding [2]) The movement of air masses also leads to abnormally hot or cold stretches as air that was normally contained to the far north or deep south. This is what causes the rapid switch we saw with temperatures like 70° on Friday and 35° on Monday.

This is also responsible for drought conditions, we see the impacts of this lately as we experience prolonged droughts followed by large

influxes of rain rather than the semi-regular, low intensity rainstorms that were normal in the past.

With this in mind, it's understood now that the climate conditions are changing as the air masses dip deeper into each other's territory more often, and regularly. This is leading to a shift, where northern areas are beginning to experience climate conditions of the south. It's expected that the climate conditions will shift north over the next century.[3]

For this reason, Long-term natural resource management plans need to consider this shift as *temperature, precipitation, and storm intensity are important factors in the success of harvests.* They impact things like flowering times, the moisture in the fields, the rate soil erosion, which lead to reduced productive capacity. We have created models for this occurrence that we call;

> "Climate Analog maps"- Climate-analog mapping is a statistical technique that matches the expected future climate at one location—your city of residence, for instance—with the current climate of another familiar location to provide a place-based understanding of climate change - https://www.umces.edu/research-highlights/climate-north-american-cities-will-shift-hundreds-miles-one-generation
>
> (^^^ *Here you can find a mapping tool created by the University of Maryland that can tell you what changes to expect according to your nearest city*)

What is the purpose of the Assisted Tree Range Expansion Projects?

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Choosing trees that can withstand these temperature shifts, droughts, and infrequent flooding while still producing fruit or other materials is important to maintain yield success and to ensure what you plant will establish and stay healthy. This is the objective of the Tree Range Expansion Projects.

> "To help forests keep pace with climate change, researchers and forest managers are looking at using a strategy known as assisted migration, which provides trees with a climate-informed "nudge" across the landscape. Essentially, assisted migration involves taking a seed or seedling from a warmer location and planting it in a new location that, due to climate change, will experience warmer conditions in the coming years, helping to ensure the tree will survive and reproduce — spawning the next generation of resilient forest."

- American Forest Association, 2024 (https://www.americanforests.org/article/trees-on-the-move-3/)

The relationship between trees, plants, and animals are what provide our society essential services like fertilization and pollination of our crop, stabilizing banks to prevent erosion, and maintaining the cleanliness and useability of our water.

It's important we factor in this information when we make decisions about our own land management strategies so we are not vulnerable to the new risks that come along with changes to the concentration of gases in our atmosphere. With foresight, we can anticipate impacts and avoid challenges to maintain access to fundamental goods like water, food, and infrastructure stability.

At the conservation district, we follow where the data goes to inform our actions when it comes to providing services that protect the quality of the land and water you live on. There is no dispute about the presence of climate change among any governmental, economic, or scientific bodies. The only disputes still out are on whether humans are the cause of the changes we see, but **changes are happening and it's our responsibility to be observant and proactive. Especially when the livelihoods of agricultural workers and communities are on the line.**

Figure 1| http://ete.cet.edu/gcc/?/globaltemp_carbon_cycle/

1. https://www.carbonbrief.org/analysis-global-co2-emissions-will-reach-new-high-in-2024-despite-slower-growth/

2. https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-mi.pdf&ved=2ahUKEwjZx5-1oqOMAxVxjYkEHYaQAAEQFnoECAoQAw&usg=AOvVaw0rFKTotl19kis2FYLy4KZ5

3. https://phys.org/news/2019-02-washington-dc-climate-deep-south.html