

Climate Science Cheat Sheet

How do we know climate change is happening? (*Climate's Heart metaphor*)

- Warming indicators observed include higher average water vapor, higher average temperature over oceans, higher average sea surface temperature, rise in average sea levels, higher average ocean heat content, higher average temperature over land, and lower average sea ice, glaciers and snow cover.
- Even though surface temperature increase has slowed in this most recent 10 year period (which is still warmest on record) simultaneously, ocean heat content has been going up faster and penetrating deeper.
- Data sub-selections of specific short periods of time or specific regions can be used to mislead = weather is highly variable, but climate is a mean state
- Local factors will determine the effects of climate change on each regional weather system= coastal regions should expect more precipitation (which in the winter means snow) when the oceans are warmer, because they produce more water vapor that enters the atmosphere. Warmer air also has the ability to hold more water vapor
- Polar vortex shift = Cold air is typically trapped over the north pole in the winter by the polar vortex circumpolar wind system, which derives its strength from the temperature difference between the pole and the equator. As we lose summer arctic sea ice coverage due to increasing global temperatures, the ocean around the pole could absorb heat from the sun that normally would have been reflected by sea ice. In the winter, when the ocean around the pole refreezes, this excess heat would be released to the atmosphere, lessening the temperature difference between the pole and the equator, thereby weakening the polar vortex and allowing for more frequent southward dips of the polar air mass, like the one that caused colder than average temperatures across much of the US this past winter.
- Changes to ocean temperature impact ability to circulate heat and moisture, resulting in too much heat and moisture in some areas and too little in others.
- Sea level rise does not occur uniformly= western North Atlantic sea level rise is enhanced because the land mass is sinking back as weight of glaciers in other areas is removed (yoga ball effect)
- Gravity pulls water toward glacial mass, so as glaciers melt, water spreads and ends up in the northern hemisphere, resulting in 25% more sea level rise
- Regional changes in circulation can also increase sea level rise locally = when gulf stream slows down, water domed in middle of current spreads to coasts

How do we know CO2 is the culprit? (*Heat Trapping Blanket metaphor*)

- Gases in the atmosphere determine what we actually feel because they absorb the sun's energy and store it as heat, increasing temperature
- CO2 traps infrared heat trying to bounce back into space
- In 2004, 29 Lake Michigans worth of emissions went into atmosphere

- Natural causes of warming like solar radiation, volcanic eruptions and natural climate phases are stable, but around mid 1970s, temperature deviates because of the introduction of more CO₂ due to human activities
- Spatial warming and day to night cooling patterns are not indicative of any of the potential natural causes that have lead to warming in the past

How do we know it's human caused? (*Regular vs. Rampant metaphor*)

- In history, major shifts in CO₂ concentration always occurred over long time spans. Current time scale is 60 years instead of millions of years
- Currently experiencing highest levels of CO₂ in several million years and a 30-100 times faster rate of change
- Atmospheric composition going back a million years can be determined from bubbles in ice cores
- Humans evolved with atmospheric carbon concentrations at 100ppm, and they are now 440ppm
- Co₂ has different isotopic signatures from natural sources or fossil fuel sources, so fossil fuel sourced carbon dates as older when tested
- CO₂ comes from fossil fuel use, deforestation, and land conversion to agriculture

What are the implications? (*Osteoporosis Of The Sea Metaphor*)

- One to six feet of sea level rise before the end of the century
- Heat causes oceans to expand, resulting in sea level rise, plus melting ice adds to volume
- By 2100, ocean acidification could cause a halving of carbonate ion concentration in the oceans
- Ocean acidification alters chemical signaling the plankton and fish need to reproduce, avoid predation, and navigate
- Economic cost of ocean acidification could be \$1trillion a year by 2100
- Phytoplankton produce 50% of the oxygen we need to breathe
- Climate change will affect geographic ranges, diversity, and relative abundance of plankton, and as they migrate to cooler waters, it will change the ecosystems that depend on them
- River deltas formed only once sea level stabilized
- Charleston issues advisories for 7-foot tides that currently happen twice a year, but with 1.6 foot sea level rise, could happen 355 times per year instead
- Sea level rise results in bluff erosion, overwash island breaching loss of coastal wetlands, salt water incursion into drinking water, and reduced water quality in areas with septic tanks
- As fisheries shift to colder waters, bird and prey migrations no longer line up and the birds die of starvation during migration
- Species ability to adapt is dependent on reproductive rate, so rate of change is important (too fast = no chance to adapt)
- Human beings are now carrying out a large scale geophysical experiment
- 1/3 of fish species rely on coral reefs

Why do we need to act immediately?

- To stabilize at current atmospheric CO₂ levels, emission would actually need to go negative, because CO₂ lingers
- Climate system has inertia through positive feedback mechanisms
- Sea ice is a bright surface that reflects solar rays and provides cooling, plus helps drive ocean circulation, so loss of sea ice is a positive feedback cycle that creates broader weather changes
- Oceanic concentration gradient: when there's more CO₂ in the atmosphere, it gets absorbed into the oceans, until more builds up in the oceans, at which point the gradient would reverse.