Hadley Cell

Currently, the overall energy in the earth's weather is increasing, but it's not evenly dispersed over the earth's surface. Some places are warming much faster than others, a few places are actually getting colder, and, just about everywhere, it's getting locally hotter and colder and wetter and dryer.

The disappearance of the Antarctic sea ice appears to be a major tipping point. The Antarctic Ocean is rapidly warming and its surface is becoming less saline. Consequently, the extent, temperature, density, and timing of the annual thermohaline pulse that pumps the geothermal heat up from the deep oceans is rapidly changing. Because of decreased salinity, until about 2016, the maximum extent of the winter sea ice around Antarctica was increasing due to a warmer freezing temperature, but due to warming air and ocean temperatures and increased particulate deposition, its duration has decreased by about 90 days, and now the winter sea ice is rapidly disappearing. This is resulting in a massive, self amplifying seasonal gain in energy absorption by the Antarctic Ocean. One result is that the deep oceans have been steadily warming for decades as the annual Antarctic thermohaline pulse decreases in strength and La Nina has dominated the Pacific, but now the building heat is rising and amplifying the normal El Nino cycle. It's likely that the El Nino-La Nina cycle will be drastically altered. Another result is the catastrophic interruption of the food cycle of krill. They hatch in the fall and their larvae feed on the under surface of the ice, but it's gone before they mature.

As the ocean that surrounds Antarctica warms, the energy that powers the Antarctic katabatic vortex is increasing, and snowfall is increasing on the continent to the point where, for a while, Antarctica was gaining mass as snowfall surpassed glacial melt. As the last of the glaciers of the Canadian Archipelago melt, for a while Greenland was becoming the only remaining major freshwater inflow into the world's oceans. Sea level rise has been as much about the expansion of warmer ocean water as about freshwater melt. Currently, the rate of Antarctic shelf ice melt has substantially increased and it's becoming clear that the ice of Western Antarctica is melting from underneath and will soon collapse, causing a very abrupt and substantial sea level rise. The melting of Western Antarctica will also substantially change the configuration of the Antarctic thermohaline pulse. The Antarctic continent hasn't melted in millions of years, but the current rate of warming is unprecedented in known geologic history.

Meanwhile, the melt rate of the Arctic Ocean is rapidly increasing, changing the extent, duration, timing, temperature, and moisture content of the cold winter air currents that flow out over the American Midwest and East Coast to the Atlantic Ocean, and from Eastern Siberia over the East Siberian Sea and the Sea of Japan. The early snow that falls on the land masses surrounding the Arctic Ocean abruptly increases its albedo, starting an early, but sporadically brief winter. The snow that falls on the ice cap insulates it, so the water stays warmer, but the air above it gets colder and variations in albedo and topography sweep chunks of a very cold polar vortex into Siberia and the American Midwest. As the world's oceans and atmosphere continue to warm, they're keeping this in check, but it's quite turbulent and, as the overall system warms, the snow is melting faster and more of it is falling as rain. This is only a very temporary condition. As it is with every body of water that melts in the spring, as the ratio of white to blue inverts, the melt rate of the ice cap changes from diameter to thickness, and it suddenly it's gone. At this point, I expect the polar vortex to dissipate and even reverse.

The Bering Strait is only about 50 meters deep by 50 miles wide and its current is almost always from the Pacific to the Arctic. Because of the major input of melting snow and glaciers on its edges, by the time it enters the Arctic Ocean, its flow is cold and has a low saline content. Its volume is negligible compared to the flow from the Atlantic. Consequently, the North Atlantic and Arctic Ocean are the cul-de-sac of the world's oceans. This creates modulations and oscillations with the rest of the world's oceans. The changes in both the Arctic and Antarctic Oceans are affecting the oscillations in temperature, speed, and timing of the Atlantic Ocean currents, and it's surface manifestation, the Gulf Stream.

The course of the Gulf Stream is determined by the winds of the Northern Hemisphere and variations in freshwater input from Greenland, Siberia, Alaska, and the Canadian Archipelago, but most of the power of the Gulf Stream is generated in the Southern Oceans, and it's rapidly increasing as the oceans warm. The increased freshwater melt from Greenland has slowed the Gulf Stream, but increasing water temperature is transferring more heat farther north. As the warmer water and the concurrent more humid air flowing north from above the Gulf Stream and the Gulf of Mexico meet the cold winter air flowing off of northeastern North America, the increasing contrast is resulting in more powerful and more extreme storms in the U.S. east of the Rocky Mountains, as well as changes in their seasons. Tornados are now year-round. The hurricanes spawned in the eastern Atlantic Ocean that cross over to North America are beginning to maintain their strength far enough north to be caught in the westerlies and follow the warmer water all the way to Northern Europe.

Because the Pacific Ocean is so much larger and the ocean currents of the Pacific Ocean are more generalized and less restricted than the Atlantic, most of the solar and geothermal energy carried pole-ward by the thermal stratification of the world's oceans happens in the Pacific. The migration patterns of the pelagic fishes of the Northern Pacific are steadily moving toward the pole; clear evidence that the Pacific is warming.

It's important to understand just how thin the atmosphere on the surface of the earth is. The Hadley Cell rises at the equator and is forced down at a seasonal average of about 30 degrees latitude. It's around 4,000 miles wide, but less than 12 miles thick, and most of its mass and thermal energy are in the first few miles. The mechanism of the Hadley Cell is different over land and ocean and is strongly influenced by their geographical relation to each other. It's also strongly influenced by the world's mountain ranges. On a 3D map of the United States on a standard size sheet of paper, the Colorado Plateau would stick up about the thickness of one sheet of paper, the mountain peaks of the Rockies about two and a half sheets, and the world's tallest mountains about the thickness of five sheets, but that's enough to channel the air currents that control our weather.

As the world's oceans warm and evaporate more water, the Hadley Cell is increasing in size and water density. This is resulting in an increase in the size, intensity, and range of cyclones, typhoons, and hurricanes, and an overall increase in precipitation. As the contrast between southern oceanic heat and more extreme northern continental hot and cold increases, it's resulting in more violent storms in the Northern Hemisphere, but it's much more concentrated at the regions of greatest contrast.

Atmospheric particulate pollution plays a major role in global climate and weather. The increase in human caused particulates and aerosols in the atmosphere over the last century has caused premature cloud seeding in the lower atmosphere, causing the cloud ceiling to substantially lower, making weather more controlled by topography, and concentrating the boundaries between hot, cold, wet, and dry. It also increases shading of the surface of both land and sea. This tends to decrease infrared radiation over land and endothermic evaporation over water, but not enough to counterbalance the greenhouse gas warming of water vapor above the dew point in combination with other greenhouse gasses. While currently increasing land and ocean temperatures tend to increase the size and moisture content of the Hadley Cell, increased particulates tend to seed clouds and decrease the atmosphere's water storage capacity. This is resulting in an increase in more immediate overall precipitation within the Hadley Cell resulting in more extremes in rainfall and an increase in the range and intensity of drought on its descending edges. Atmospheric particulates are a major player in the current increases in both flooding and desertification in both the northern and southern temperate zones.

The massive increase in wildfire around the world is substantially affecting both climate and weather by increasing greenhouse gasses, by reducing the albedo of snow and ice and by increasing cloud seeding. They're turning into another tipping point. Forest fires are on the increase at the moment and emit large quantities of CO_2, black carbon and a variety of other particulates which warm the atmosphere and melt the glaciers. In the atmosphere, the effects of black carbon are short lived, as most of it settles out in a few weeks to a few months. The effects of black carbon on glacial melt last much longer, as it tends to accumulate on the surface of the ice, where it converts solar energy into the infrared spectrum that melts snow and ice. Most of the glaciers in the Southern Hemisphere have been coated with a layer of fine ash from the Australian fires, thus greatly increasing their melt rate, although the ash from eucalyptus is tan rather than black like the ash from the northern hemisphere conifers. The fires in northwestern North America are substantially increasing the melt rate of the ice sheets of Greenland and Iceland. Their glaciers are heavily coated with a layer of ash and a variety of human caused particulates. They're various shades of gray to black. Meanwhile, the massive dose of CO_2 generated by the fires is a major contributor to atmospheric warming, and will remain in the atmosphere for decades.

A major contributor to global warming that is largely overlooked is direct heat from combustion. Adding to the background heat from the fossil fuels we're burning, the increase in fires all around the world are a self amplifying addition to the warming, although there's much more fire in the engines of the cars and trucks on our roads than in all the wildfires.

There's a new kind of smoke appearing in our atmosphere. The new suburban crown fires, e-waste fires, and landfill fires are producing a very complex and very toxic smoke on a scale large enough to affect climate. Look around your house and visualize everything vaporized and multiplied by a billion. Many kinds of finer aerosols can stay in the atmosphere for years, much of it in the stratosphere, where they mostly reflect and shade. Composed mostly of sulfates, they are a major player in the overall albedo of the earth, and counterbalance the warming effects of greenhouse gasses, but we don't know much about a lot of what goes up in smoke these days. The short and long term effects of the multitudes of atmospheric emissions resulting from this civilization's consumption addiction are becoming an unknown factor in weather and climate. We've blown the lid off Pandora's Box.

The decline in human activity cause by Covid 19 caused a very sudden drop in the aircraft and oceanic shipping condensation trails that create lines of reflective clouds, and a sudden drop in atmospheric particulate pollution until the wildland fires quickly brought it back up. This abruptly altered the balance between atmospheric particulates which shade the earth's surface but melt snow and ice, and greenhouse gasses that capture infrared radiation from the land. This caused increases in evaporation from the oceans and increased heat generated by the earth's land masses. Greenhouse gasses only operate over land, as the oceans reflect very little in the infrared spectrum. Land transfers solar energy to the atmosphere by re-radiating most of it in the infrared spectrum. The world's oceans store and stratify solar energy, carrying it toward the poles and transferring it to the atmosphere through the endothermic evaporation and exothermic precipitation of water. Because greenhouse gasses take many times longer to dissipate than particulates, in the short term, this very briefly exacerbated global warming. As we come out of the pandemic, this is quickly reversing as our level of consumption goes back up.

So far, increases in efficiency have not resulted in a decrease in greenhouse gas production. Efficiency just lets us consume more. We're hardcore energy addicts. Cleaning up particulate smog without a corresponding decrease in greenhouse gasses should result in a substantial increase in atmospheric and ocean temperatures with a concurrent increase in the size and water content of the Hadley Cell, and it should decrease cloud seeding in the tropics; thus allowing more moisture to reach the descending edges of the Hadley Cell, driving some of the deserts further towards the poles.

At some point in the not too distant future, we'll either get our shit together or this civilization will collapse. Either way, human caused greenhouse gas production will decline. In combination with a blue Arctic Ocean, this has immense potential to turn the northern continents white. We could ride the pendulum into cold just as fast or faster than our pollution has yanked it into hot. It could happen in a hundred years or many thousands depending on a number of other factors. A lot depends on the tundra. Will the new snows from a blue Artic Ocean happen soon enough to change the tundra's albedo and stop the melt, or will greenhouse gasses win out and it rains instead of snows

It took a billion years for the earth to concentrate solar energy into the hydrocarbon fossil fuels that we so glibly burn in our frenzied addiction to consumption. At our present rate of consumption, we'll use it all up in just a few hundred. What next?