Surprising facts about polar bears: (1) They have survived other periods with temperatures warmer than today; (2) the number of bears declined due to overhunting during the 1960s; (3) although their numbers have rebounded since, several hundred are still hunted annually. *Female polar bear, Barter Island, Alaska, 2007.*

1 A Map for the Climate Battleground

The best projections tell us that we have less than 100 months to alter our behavior before we risk catastrophic climate change.

– Charles, Prince of Wales, March, 2009

When I enter conversations with people about global warming, which I do warily, I ask them for proof that it is taking place and for proof that it is being caused by humankind. In most cases, merely asking these questions is considered to be in bad form. Those who are willing to respond to the questions typically appeal to authority: "I know that it's happening because figures in the media and the scientific establishment told me so." When I point out that this is not proof, the individual typically invokes polar bears and the melting of ice caps, two things that I used to worry about myself.

It's at this point in the conversation that I mention that the sea ice around Antarctica, since it started being measured by satellite in 1979, has *increased* and that the record maximum value for the ice occurred in 2007. If I'm feeling courageous, I add that polar bear numbers have swelled during the last 40 years, after an intense period of over-hunting. Most people who

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believe that human-caused global warming is one of the great problems of our age generally cut the conversation short at this point. It is clear to them, from the evidence presented, that yours truly is in possession of some highly annoying pieces of information and probably not to be trusted.

Believe me, I understand how confusing it is to learn of little-known facts like these. This is especially the case with the media trumpeting, daily, catastrophic sea-ice melt in the Arctic basin, more so following 2007's impressive melt season. But 2007, with the record melt and record ice accumulation at opposite ends of the Earth, may not be so unusual at all. We have been examining sea ice from space, using satellites, for a remarkably short period of time. Pronouncements about the significance of trends in the floating ice (decreasing in the Arctic and increasing in the Antarctic) during the last 30 years are best taken with a grain of salt.

And this is part of a bigger picture. Other means of witnessing weather and climate in new ways, in addition to satellites, that make atmospheric phenomena hyper-visible are at least part of the reason why people have come to fear nature again, in ways perhaps not seen for centuries. Some of the other technologies underlying the palpable sense of fear include: video cameras, cable TV, and the Internet. Combined in human consciousness in unprecedented ways, these digital tools have given a lot of people, among them many scientists, the sense that both weather and climate have gone haywire. Thus, when authoritative commentators intone that weather has never done this before, while images of people waist-deep in floodwaters flicker across your TV screen, the *only* moral position becomes to align your sympathies against whatever caused this devastation. Unfortunately, things are nowhere near this straightforward. Weather and climate catastrophes have been killing significant numbers of our species since we first came into existence. Any one of hundreds of vicious storms, for instance, from the last several thousand years, if it were to happen again today and be televised could be taken as proof of "climate change." Despite such a modern lack of perspective, from floods to fires to two-hundred-year droughts, it has already happened before, and, in all too many cases, frequently.

These things didn't only happen in the distant, Biblical past, but merely in the dark void of pre-television. As the last few decades demonstrate, nothing televises so well, or captures the imagination as engagingly, as storms. There is a reason that the average local newscast now contains three or more specific weather segments in a 21-minute broadcast. And the constant air-time that weather now receives, on our iPhones, laptops, desktops, TVs, and cinema screens, has produced a distorted sense that weather used to be benign and has suddenly become menacing.

My own interest in weather has always been intense. When the weather segment came on during the TV news when I was a kid, I would leave whatever

conversation I was in, chore I was performing, or the dinner table, to go watch the forecast on Channel 7 from its lead meteorologist, Pete Giddings. That the forecast usually meant, as close to the Pacific Coast as I was, "continued foggy mornings and sunny afternoons" did not dissuade me a bit.

On the other hand, there were occasions when we got less subtle weather where I grew up: Pacific storms, thick with rain and wind, that could and did cause blackouts, clear-sky windstorms, the occasional thunder and lightning, and, in 1974, a snowstorm that left five inches of the most magical substance on Earth in my yard. It makes my stomach clinch up thinking of it, as though for a lost love, 37 years later. Around this same time, my mom taught me a secret: Snow like that at our house that day was frequently just up the road that led to the top of the Santa Cruz Mountains, a drive that she took with my sister, myself, and one friend each on several occasions, carrying our sled in the trunk.

In high school, I still had the sled, and a driver's license. Several times a winter, I drove to the top of the Santa Cruz Mountains, eased myself through a barbed-wire fence, and took the first of many runs down a steep, seldom-used cow pasture hidden from view of the road.

For someone as interested in weather as I, what happened after high school was almost too good to be true: acceptance at Dartmouth College – and complete immersion in the four full-fledged seasons of Northern New England. When the first snowflakes flew sometime in early December of my freshman year, I could be seen in the picture window of Wheeler Dormitory's stairway landing between the third and fourth floor, nose pressed against the glass.

I found a new sport in the new environment: crew. I was soon out on the Connecticut River in all the weather that New England could deliver. More than with a lot of other sports, when your coach tells you that you'll be rowing today, you simply endure whatever comes your way: rain, snow, thunderstorms, wind, frost, sun. When the river was frozen, which it was a lot, we ran and cross-country skied on packed snow paths around town. As a result, we enjoyed winter more than most of our hibernating peers, and my love affair with snow deepened.

Some years later, I came to witness while living in New England again how stressing and dangerous ice, snow, and cold are. Partly my observation came from shoveling my own driveway and those of some relatives and neighbors. Partly it came from editing the obituaries at a newspaper in Massachusetts and taking note of a spurt of deaths during each cold snap. Finally, my observation came from running a woodstove as my primary source of heat for two years. Winter, prior to our modern conveniences, was an ordeal, survived through hard work.

This is what makes it so bizarre that anyone has associated the colder temperatures of yesteryear with prosperity. It has so far not been the case, in human history, that cold times have been good times. And once you come to understand how wrong scientists are

on this one point, the question presents itself: What else have they got wrong?

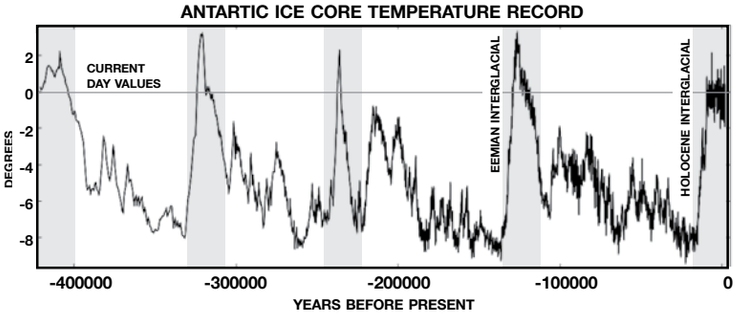
Answering this question requires learning some climate vocabulary. For starters, although people typically discuss global warming in terms of the atmosphere, it is more useful to consider the atmosphere and the ocean together. A term has been developed to facilitate this linkage: the **ocean-atmosphere system**. If you want to warm the atmosphere meaningfully, you have to warm the seas, which cover 66 percent of the planet, as well. That's not easy, given the incredible **heat capacity** of water. Throw a bucket of 125°F water on your body, and it will leave a large red mark. Let a fan blow the same amount of 125°F air on your body, though, and you will barely notice. Water holds a lot more heat than air. On the planetary level, the heat capacity of the entire atmosphere is equivalent to just the top ten feet of the world's seawater. When scientists say that the atmosphere will warm a given amount because of carbon dioxide emissions, they mean that the oceans and the air will both warm, but, again, heating such a water-dominated system is an extremely difficult task.

Despite this difficulty, it does happen. The geologic record is rife with significant ocean-atmosphere warmings, and coolings. One such cool-down, on a major scale, began about three million years ago, as the planet slid into the current **Ice Age**, one of dozens of various lengths that have occurred during the planet's 4.5 billion-year existence. Since the start of the Ice Age, Earth has been in a deep freeze, with significantly

The distance separating Florida and the island of Cuba has varied for millions of years, due to changes in the amount of water captured in ice globally. No single distance is more "natural" or "perfect" than any other.

colder oceans than today, for 90 percent of the time. Our modern days are part of a relatively rare respite in the harsh conditions, such interruptions being called **interglacials**.

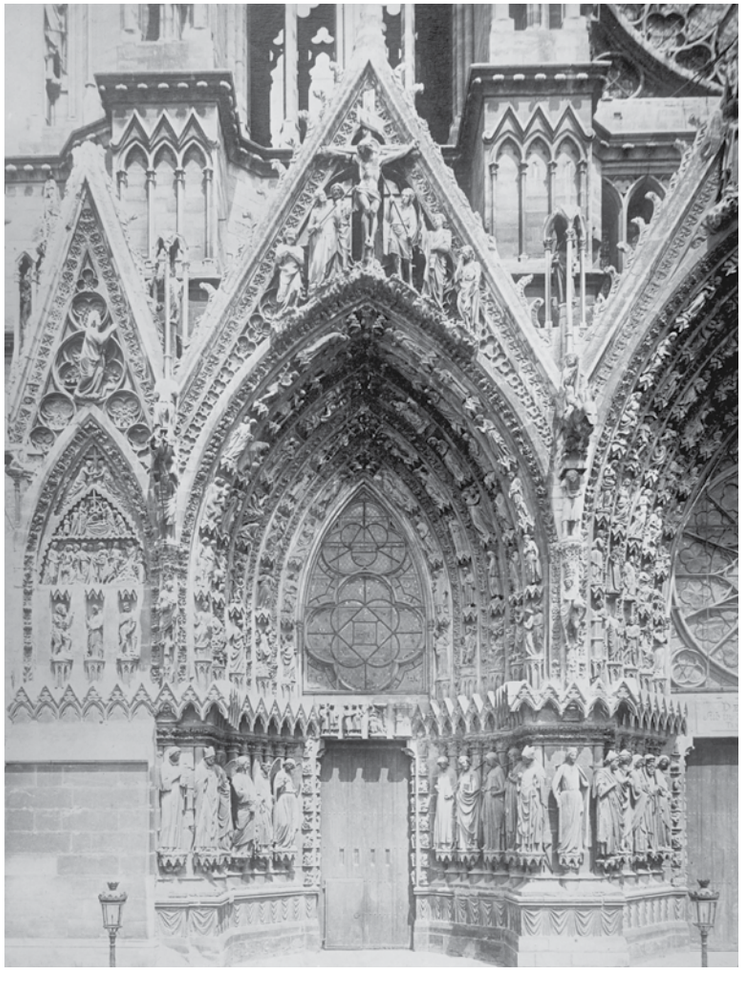
When the true Ice Age conditions reign supreme, the cold yields several important consequences, the best known of which are mile-thick ice sheets, covering the greater part of North America, the British Isles, Scandinavia, and a wide strip of Russia. The ice sheets,



The ice core temperature record from Antarctica shows the relatively cool Holocene interglacial near the right edge of the graph, with the current time represented as Year 0. Temperatures are shown as anomalies, with the Holocene mean temperature taken to be zero. The temperatures of the interglacial prior to ours, the Eemian, about 120,000 years before present, are deemed natural by certain scientists. But any further warming during the Holocene has been presumed by the same scientists to be unnatural.

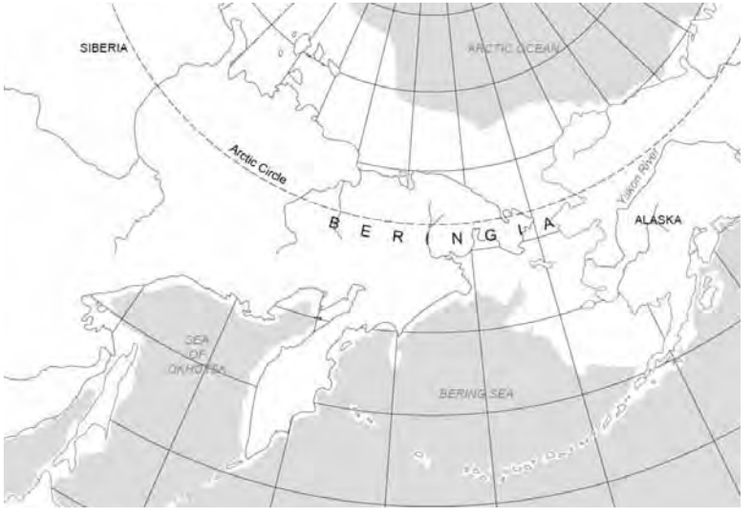
in turn, have multiple important effects, one of which is removing immense quantities of liquid water from the seas. That is why Ice Age sea level has typically been about 400 feet lower than today. As you would expect, the results of the lower sea level have been extraordinary, from our perspective. Australia has usually been joined by land to New Guinea, likewise England and France. Much of what is now the island realm of Indonesia has been a solid mass that extends to within 600 miles of Australia. The Gulf of Mexico has been far smaller than today; the Florida peninsula has been twice its current width.

Although occupying only ten percent of the Ice Age timeline, interglacials, normally lasting about 10,000 years each, are scattered in the geologic record at roughly 100,000-year intervals. This means that, in terms of favorable climate, those of us alive in the twenty-first century are about as lucky as we can be.



The construction of Gothic cathedrals took place during the climactically benign Medieval Warm Period. The cathedral at Rheims, France, exemplifies the opulent display of resources made possible by the era.

The name of our relatively comfortable climatological nest, which came into existence 12,000 years ago, is the **Holocene interglacial**. It is all well and good for people to argue about what has taken place during the Holocene, which they do, but one thing has to be kept in mind all the while. The Holocene will not last

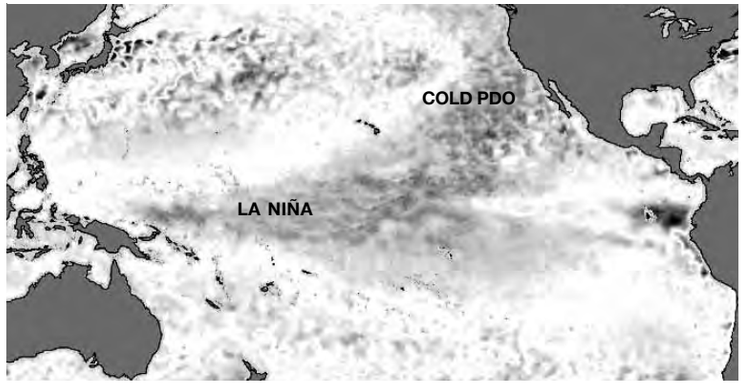


During the next period of widespread glaciation, the sizable region connecting Asia and North America is likely to emerge again. *Beringia, 20,000 years before present*.

forever. One day, anywhere from ten years from now to 10,000 years from now, the inevitable slide back into full glaciation will occur. With that return to cold will come new, almost unimaginable, challenges in feeding the world's vastly increased population since the last time the ice sheets were present. One of the changes that the Holocene produced was Chesapeake Bay, which formed when the rising waters associated with glacial melt flooded the Susquehanna River Valley.

The **Holocene Optimum**, a period warmer than our own, started 8,000 years ago and ended 6,000 years ago. Warm periods in Earth's past have been called optimums by climatologists, because the overwhelming majority of life forms on the planet, including human beings, thrive in relatively warm conditions. It happens to have been during the Holocene Optimum that

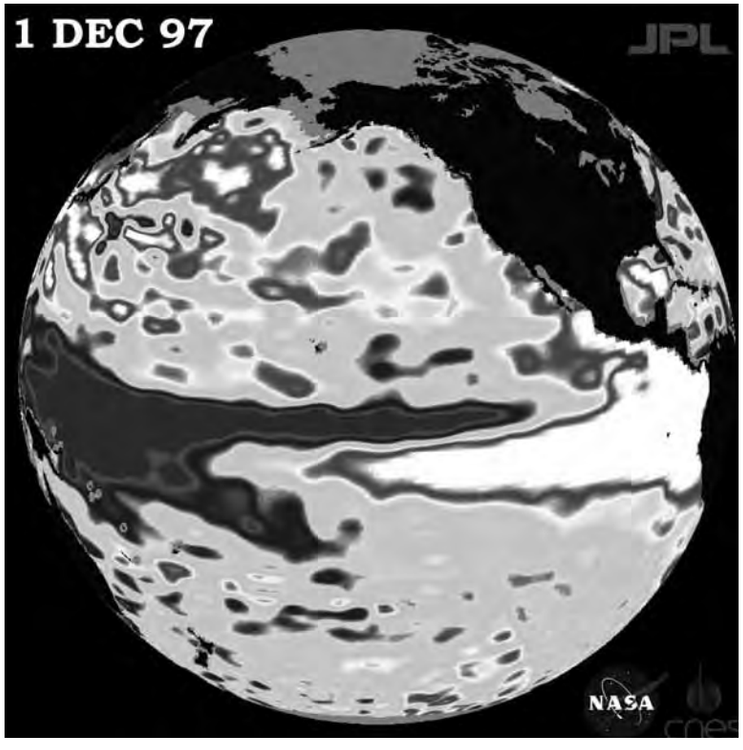
COLD PACIFIC DECADAL OSCILLATION



Cold water, in grey, some related to a La Niña and some related to the cool phase of the Pacific Decadal Oscillation, is shown across much of the Pacific Ocean. La Niñas, which last a year or two, are more common during the cool phase of the PDO, which lasts about 30 years. The most recent cool PDO, during which relatively cold water resides on the surface of the Pacific most of the time, began in 2006.

agriculture began to be practiced by our forebears and permanent habitations became increasingly common. After the Holocene Optimum came a cool phase, with less optimal growing conditions, which concluded around 200 B.C. At that time, a warm period known as the **Roman Climatic Optimum** began, and it lasted 500 years. The good growing conditions were a core reason for the Roman Empire's success, and although it would be an exaggeration to say that it all collapsed merely because of a cooling climate, colder temperatures and failed crops were at least partly to blame for the fall of Rome.

Starting in about the year 1000, after this harsh stretch, came a far more forgiving climatological time known as the **Medieval Warm Period**. During the next three and a half centuries, sea ice that had encircled



The great size of the Pacific is such that relative warming and cooling over the ocean's equatorial waters have worldwide effects. *The Super El Nino of 1997-98, a tongue of warm water shown in white, stretches across the Pacific.*

Iceland melted. Vikings sailed for Greenland and began a colony that lasted for 350 years. The arts flourished in Europe, as exemplified by the great Gothic cathedrals of the era. Famines became a rarity, and population grew.

Beginning in about the year 1300 and lasting until about the year 1850, came another cold time – the **Little Ice Age**. Winters were brutal; summers were short; alpine glaciers grew; crop failures became frequent; witch burning was prevalent; wars raged; diseases, typified by the Black Death, claimed whole cities and towns. Ironically, despite its many hardships, the Little Ice Age largely established our understanding of what normal is, in terms of glaciers, sea level, and temperature. For, the glaciers that we assumed to have lasted throughout human history had in fact advanced to their (modern) maximum size towards the middle of the 19th century, only a handful of generations ago.

As for the terms to describe our current ocean-atmosphere conditions, I will introduce a few here. First is a 60-year cycle in the largest ocean on Earth, the **Pacific Decadal Oscillation**. While all of the oceans are significant in determining atmospheric conditions all around the globe, the one that calls the shots the most often on a global level is the Pacific. The most widespread and influential cycle in this vast liquid wilderness is the Pacific Decadal Oscillation. Referred to by experts simply as the **PDO**, the Pacific Decadal Oscillation has a 30-year warm phase and a 30-year cool phase.

The 60-year cycle has a relationship to the better-known phenomena of **El Niños** and **La Niñas**, shorter-term events known by people around the globe to spur both droughts and floods as well as warm and cold temperatures, depending on the part of the world in which you live. For the southwestern United States, El Niños are warm, precipitation-enhancing events, and La Niñas are cool and dry. In the southern and eastern United States, El Niños are cold and wet, and La Niñas are relatively warm and dry.

In the simplest terms, an El Niño is a superficial

band of warm water extending along the Equator between Indonesia and Peru. The largest, most intense El Niño measured by scientists formed in 1997 and lasted through early 1998. On temperature-anomaly maps, showing the departure from normal sea surface temperatures, the so-called "Super El Niño" looked like a bright-red tongue extending two-thirds of the way across the Pacific. The band of warm water was so large in size and so warm that it spiked the **global mean temperature**, an average of sea surface and air temperatures around the world, to the highest point that it had ever attained.

El Niños are complex in their genesis. Broadly speaking, they are born in the following sequence of events: (1) water, pushed by westerly **trade winds**, piles up in the eastern Pacific; (2) the vertical Sun over the Equator hits the accumulated water long enough to warm it, creating an enormous, superficial "warm pool"; (3) the trade winds slow down, or even reverse, moving from east to west; (4) pockets of warm water the size of Mexico slosh back toward the western Pacific, in what are called **Kelvin waves.**

La Niñas, conversely, are superficial pools of unusually cool water lying along the Equator. One of the most significant of these took place in 2007 and 2008. That La Niña, which on temperature-anomaly maps resembled a deep blue band stretching two-thirds the way from Peru to Indonesia, briefly cooled the global atmospheric temperature by just about the same amount that it had risen during the previous 100 years.

La Niñas are hatched in more or less the opposite process as the one leading to **El Niños**. Rather than slowing down, the dominant west-to-east trade winds speed up, pushing water towards the west. Cold water wells up along the coast of South America and then moves along the Equator, propelled by brisk trade winds. More cool water is brought to the surface along the Equator by the wind as the top layer of the ocean overturns.

When the Pacific Decadal Oscillation, a cycle arguably underlying American weather journalism for the last century and a quarter, sits in its 30-year warm phase, El Niños are relatively powerful and relatively frequent, and the global mean temperature tends to increase. You can experience a La Niña during a warm PDO, but it is usually a weak one. Conversely, when the Pacific Decadal Oscillation is in its 30-year cool phase, La Niñas are more prevalent. When the 1997-98 Super El Niño occurred, it was about two-thirds the way through the warm Pacific Decadal Oscillation of 1978 to 2005.

It is no coincidence that widespread concern about manmade (so-called anthropogenic) **global warming** got going during the recently ended warm phase of the Pacific Decadal Oscillation. Conversely, talk of an Ice Age was all the rage as the cool phase of the Pacific Decadal Oscillation played out some thirty years ago. This is a point that cannot be overemphasized. As world temperatures have stabilized since 1998, causes of the last century's global warming are finally being debated.

As that debate unfolds, three points are worth

bearing in mind: (1) Planet Earth – its ocean-atmosphere system, to be precise – has been cooling since the Holocene Optimum, which ended 6,000 years ago; (2) civilization has flourished during periods of warmth, including and especially during the last 150 years; (3) the time of most extensive glacial coverage during the entire Holocene interglacial was the Little Ice Age, which ended just a century and a half ago.

All of this is suggestive of the simple fact that climate changes, and has always changed. Wishing for it to do otherwise is anti-Nature and anti-science. As the philosopher George Santayana said, "To be interested in the changing seasons is a happier state of mind than to be hopelessly in love with spring."