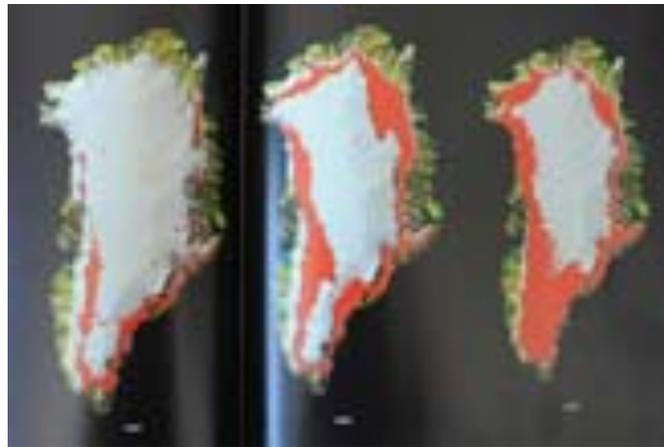


Will the Greenland Ice Cap Melt?

By Norman Rogers

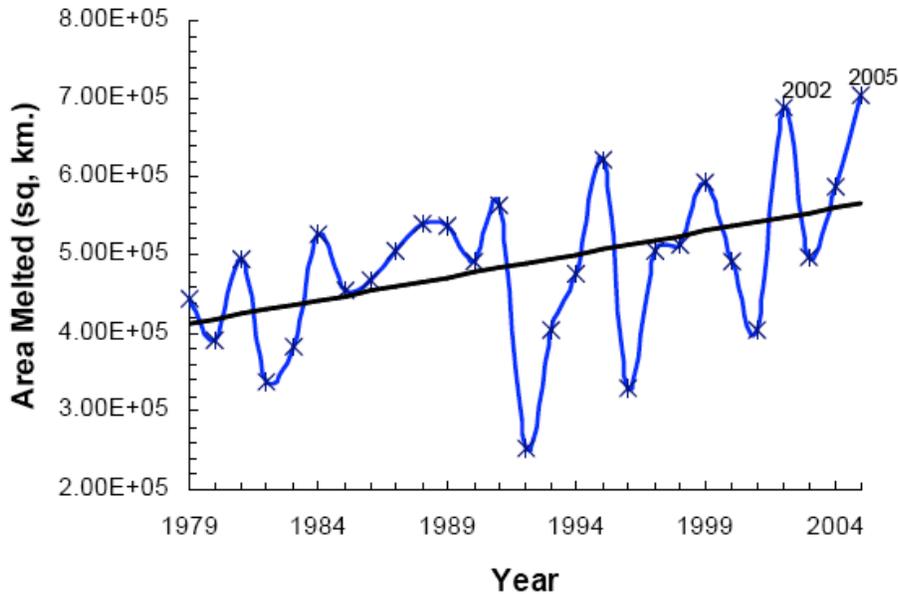
Greenland is the world's largest island. Most of it is above the Arctic Circle and nearly all of it is covered in ice that is often more than a mile thick.

Al Gore's book **An Inconvenient Truth** has 14 pages on the melting of the Greenland ice cap complete with numerous inundation maps showing what would happen if the ice cap vanished and sea level rose by 18 or 20 feet. Gore is never specific as to how or when it would melt. He only tries to scare us with a *what if it melts* story. Gore prints maps showing where the surface of the ice cap melted for at least a day in 1992, 2002 and 2005. Satellites can detect melting on the ice surface because there are optical differences between snow and liquid water. He selects years designed to exaggerate the trend toward increased melting, picking his first year as 1992, when melting was at a 25 year minimum, and picking his later years as 2002 and 2005, years when there was maximum melting.



Gores's 3 Maps of Greenland Melt Extent in **An Inconvenient Truth** for 1992, 2002 and 2005

**Extent Experiencing at Least 1 Melt Day
April - September 25**



Satellite derived Greenland melt area from the University of Colorado. Al Gore chose to depict only 1992, 2002 and 2005 to show a melting trend.

Source: <http://cires.colorado.edu/steffen/greenland/melt2005/melt2005brief.pdf>

The graph above shows a warming trend as exemplified by the increase in the melting extent. Similar warming trends, only stronger, have been experienced in the past. A recent scientific paper¹ compared the Greenland warming from 1995 to 2005 with earlier periods of warming. The authors concluded that almost all decades between 1915 and 1965 were warmer than the current one and that the warming from 1920 to 1930 was 50% more rapid than the current warming. We had a lot more reason to be alarmed about Greenland temperature trends back in 1930 than we do today. Unfortunately there were no satellites to observe those warming trends.

The Laurentide ice sheet that covered much of North America took about 15,000 years to melt. That ice sheet was mostly far to the south of Greenland and during the period it was melting summer sunlight in the northern latitudes was about 10% stronger than it is now. The variation of sunlight is caused by astronomical variations in the earth's orbit and in the inclination of its axis. For the last 5 or 10 years Greenland has been losing about 100 cubic kilometers of ice per year, sufficient to remove the ice sheet in a brief 30,000 years. There is no reason to think this is the start of an accelerating trend other than the predictions of the IPCC. The current Greenland ice loss trend is not alarming. It is not

¹ Greenland warming of 1920-1930 and 1995-2005 by Petr Chylek et. al. Geophysical Research letters (2006)

reasonable to use it as evidence of a coming disaster. Given the temperature history is reasonable to assume that stronger ice loss trends existed in the early 20th century.

A lot of snow falls and accumulates in at least parts of Greenland. World War II planes that force landed on the ice cap were recently dug out of nearly 100 meters of snow and ice that had covered them. Generally the most extreme global warming alarmists don't claim that the ice cap could melt in less than several hundred years. But there is no proof that it will melt at all, or slide into the sea either. Melting of the Greenland ice cap makes for dramatic maps, but it is strictly hypothetical. Much of the ice cap is at high altitude due to its great thickness. It is extremely cold at the higher altitudes with average annual temperatures well below freezing. Probably the ice cap has grown since the Middle Ages because southern Greenland was formerly inhabited by Scandinavian farmers who were driven off by the cold climate of the little ice age that started around 1300 AD.

On the coasts of Greenland there is no ice cap and the weather is well above freezing for the summer months, even in the far north. At Thule on the northwestern coast, at 76.6 degrees north latitude and 500 miles above the Arctic circle, the average high in July is 45 F. But once you get away from the coast, the ice cap is so thick that you will be at high altitude where the temperature is rarely above freezing, even in the summer. So, in the vast interior of Greenland, snow accumulates and very little is removed by melting or sublimation². Instead it piles up and compresses the older snow into ice. The great ice cap slowly flows toward the coast because ice under the pressure of hundreds of meters of ice above becomes plastic and can slowly flow. The plasticity of ice is greatest when the ice is warm, near its melting point, and declines dramatically at the colder temperatures that prevail in much of the Greenland ice cap. The flow actually takes place fastest near the bottom of the ice where it is heated by geothermal heat rising from the earth. The ice flow that reaches the coast melts or calves icebergs. At the current time the snow accumulating in the interior is balanced by ice flowing toward the coast and the total amount of ice in the ice cap is very nearly constant, not losing or gaining more than about 1/10,000 of its volume each year³. However if the ice cap vanished and the interior of Greenland instead of being at high altitude was at a lower and warmer altitude the snow that fell each year might completely melt each summer and a new ice cap would not be able to form, at least until the next ice age. There is evidence that the Greenland ice cap did mostly melt 130,000 years ago in the interglacial between the last two ice ages. That previous interglacial was considerably warmer than the interglacial that we currently enjoy and the oceans were 4 to 6 meters higher.

On the Greenland ice cap near the coast, at lower altitudes, more snow melts each year than falls. In this area, called the ablation zone, where the ice flowing from the interior is destroyed. The line that marks the upper end of the ablation zone is called the equilibrium line where snowfall and melting are equal. Another line above the equilibrium line is called

² Sublimation is ice evaporating without passing through a liquid state.

³ The article **Grace observes small-scale mass loss in Greenland** by Wouters et. al. Science (2009) gives the net ice loss measured by gravity sensing satellites for the years from 2003 to 2007 as: 30, 111, 229, 134, 270 gigatons. A gigaton of ice is about 10% more than a cubic kilometer of ice and 270 gigatons is close to 1/10,000 of the mass of the ice cap.

the runoff line. Between the equilibrium line and the runoff line some melting takes place and some of the melt water escapes toward the ocean. Above the runoff line water that melts doesn't go far and instead refreezes in the snow. Yet another line, at yet higher altitude is the melt line⁴. Above this line the snow surface typically does not melt. These lines are conceptual and must be based on criteria that take into account typical behavior rather than constantly moving the lines based on transient hot or cold spells or snowy or dry years. At some locations the ice forms into coastal glaciers or rivers of ice that reach the ocean and *calve* icebergs.

In order for the ice cap to disappear either precipitation has to decrease or it has to get warmer. If precipitation decreases and the flow of ice toward the sea continues, as it would, the ice cap will gradually get thinner. If it gets warmer then the runoff line will move toward the interior and the edges of the ice cap will be eroded beyond their present position. If the ice becomes warmer, which would take a long time, it will flow faster, further thinning the ice cap. As the ice cap thins its altitude becomes lower and this moves the runoff line inland. One problem is that increased warmth usually results in increased precipitation. So, a warmer climate will not necessarily shrink the ice cap and could even enlarge it if increased snow enlarges the ice cap faster than increased warmth shrinks it. Most analysts think that warming will tend to exert a net shrinking effect on the ice cap, but the opposite is possible and has support in the record of the last ice age⁵. If the ice cap grows and if new ice caps start to form in the Arctic, that could mark the start of a new ice age and ocean levels would fall, perhaps by the same 7 mm per year that they fell at the start of the last ice age.

Approximately 500 cubic kilometers of ice is added to the ice cap each year by precipitation and an approximately equal amount is lost by melting and iceberg calving. The ice cap contains about 2,800,000 cubic kilometers of ice. Let's say that losing 10% of the ice would be alarming because it would raise sea level by 2 feet. If precipitation stops it would take about 600 years to lose this much ice at the current rate that ice flows to the coast.

However the scenario promoted by the global warming alarmists is that the temperature will increase and the ice sheet will melt. The EPA⁶ commissioned a study⁷ that assumed that Greenland temperature would rise 6 C per century for the next two centuries. Using a model of the ice cap they predicted that sea level would rise, due to ice cap melting, approximately 15 cm, or 6 inches, after 100 years⁸ and 70 cm, a bit more than 2 feet, after 200 years. The 6 C rise for the first century is consistent with IPCC model projections where polar temperature increases faster than world averages. However the 6 C rise in the second

⁴ The Probability of Sea Rise, US Environmental Protection Agency 1995. P. 65.

⁵ **Will greenhouse warming lead to northern Hemisphere ice-sheet growth?** By Gifford H. Miller and Anne de Vernal. *Nature* 16-january 1992 p. 244. They present evidence for strong ice sheet growth in conditions similar to today due to high precipitation induced by a warm but not too warm climate.

⁶ United States Environmental Protection Agency

⁷ EPA 1995 page 72

⁸ The IPCC also predicts a rise due to thermal expansion of the ocean of about 1 foot.

century is rather extreme even for climate alarmists. The reason is that the effect of global warming caused by CO2 is not linear and the rate of CO2 emissions would have to accelerate during the second century to keep the rate of temperature increase the same, at least according to the IPCC.

The EPA has conveniently produced another report⁹ describing the effects of a sea level rise on the U.S. According to this report about 58,000 square kilometers of land is within 1.5 meters of mean sea level. Land below 1.5 meters is approximately the land that would be subject to flooding given a 2-foot rise from the Greenland ice cap melt, a 1 foot from thermal expansion of the ocean, and an additional 0.5 meter from high tides. This is about what would be expected if things get as warm as the IPCC predicts and you accept the EPA Greenland analysis¹⁰. An additional 35,000 square kilometers of the U.S. is between 1.5 and 3.5 meters above sea level. From the maps published in the report it is apparent that most of the land subject to flooding from a 1.5 meter rise in sea level is uninhabited swamps. This land is mostly on the gulf and Atlantic coasts and includes land that has been sinking for many years. A 3.5 meter rise, which is 11 feet, would only flood an additional 35,000 square kilometers, but some important inhabited areas would be flooded, especially the southern 50 miles of metropolitan Florida. Of course, even under the most alarmist scenarios a 3.5 meter rise is many hundreds of years into the future. This amount of land within 1.5 meters, or even 3.5 meters, of sea level is a tiny part of the U.S.¹¹.

The problem with fleshing out alarmist predictions with elaborate investigations such as models of ice sheets and maps of coastal inundation is that it gives the alarmist predictions a substance that they don't deserve. For illustration from a slightly different field of alarmism science, consider that the World Wildlife Federation put out a press release on 15 September 1999 that included the following statement:

The warning is accompanied by a new analysis of the latest science of warming oceans and Atlantic hurricanes by the WWF Climate Change Campaign (1). The analysis points to global warming acting as the priming mechanism for stronger hurricanes. It concludes that the Atlantic may find itself "ripped apart by a barrage of super-hurricanes during La Nina years."

Suppose we cook up a theory, supported by computer models and scientists giving press conferences, that the hurricanes will be much stronger, with 250 mile per hour winds and much more frequent with 2 or 3 a week landing in the U.S. In no time at all everything within 100 miles of the coast that isn't a bomb shelter would be destroyed. If we start investigations into construction of hurricane resistant buildings and provide anchors in parking lots so cars won't blow away, people will start to think that our hurricane theories must be true. Al Gore could write a book called **Future Hurricane World**.

⁹ Maps of Lands Vulnerable to Sea level Rise: Modeled elevations along the U.S. Atlantic and Gulf Coasts by James G. Titus and Charlie Richman (U.S. EPA 2000)

¹⁰ The alarmists like to postulate the collapse of the west Antarctic ice sheet as well. Due to ice sheet collapse fatigue and the cooling of the Antarctic outside of the relatively tiny Antarctic Peninsula we leave that analysis to others.

¹¹ Of course other countries would also experience flooding but this book focuses on the U.S. The alarmists can make claims far faster than we can bat them down so we focus on their credibility rather than trying to prove everything they say is wrong.

Alarmist predictions are easy to make and hard to refute. For example, the prominent advocate of global warming, James Hansen, wrote a 30 page paper¹² in which he says:

(d) Planet Earth today: imminent peril

The imminent peril is initiation of dynamical and thermodynamical processes on the West Antarctic and Greenland ice sheets that produce a situation out of humanity's control, such that devastating sea-level rise will inevitably occur.

Hansen's long paper has many scientific references and would generally be plausible to someone who is not expert in the field. Cliff Ollier, a professor at the University of Western Australia, has this to say about Hansen's predictions concerning ice sheets¹³:

Hansen is a modeller, and his scenario for the collapse of the ice sheets is based on a false model. ... Hanson's model, unfortunately, includes neither the main form of the Greenland and Antarctic Ice Sheets, nor an understanding of how glaciers flow. ... In reality the Greenland and Antarctic ice sheets occupy deep basins, and cannot slide down a plane. ... Except around the edges, ice sheets flow at the base, and depend on geothermal heat, not the climate at the surface. It is impossible for the Greenland and Antarctic ice sheets to 'collapse'....

Some of the present-day claims that ice sheets 'collapse' are based on false concepts. Ice sheets do not melt from the surface down – only at the edges. Once the edges are lost, further loss depends on the rate of flow of the ice. The rate of flow of an ice sheet does not depend on the present climate, but on the amount of ice already accumulated, and that will keep it flowing for a very long time.

Hansen is undoubtedly brilliant and charismatic. He has a following among both the press corps and scientists. But his mask of objectivity slips when we find out that he wants the government to prosecute CEO's who disagree with his radical global warming views for crimes against humanity¹⁴. Hansen is so popular with the Washington press corps that he received a standing ovation at a June 23, 2008 speech at the National Press Club *before he said anything*¹⁵. It is difficult to understand why the press corps likes Hansen. Does Hansen also want to put reporters who “dispute what is understood scientifically” in jail along with the CEO's? Probably they like him because they disliked Bush whom Hansen taunted. Now that Hansen is criticizing the Obama administration he may lose popularity with the press corps. Being a leader, brilliant and charismatic can be admirable but it can also lead to a state where the possessor of these qualities loses his sense of proportion, and reaches a tipping point where he begins to think he is infallible. The example of Linus Pauling is instructive. Pauling was born in 1901 and had a scientific career of undoubted brilliance, including the

¹² Climate change and trace gases by James Hansen et. al. Phlosphical Transactions of the Royal Socitey (2007).

¹³ THE GREENLAND-ANTARCTICA MELTING PROBLEM DOES NOT EXIST by Cliff Ollier <http://www.globalwarming.org/files/Melting%20No%20Problem.pdf>

¹⁴ On NPR's Diane Rehm Show on June 23, 2008 Hansen said: "...CEO's of these large energy companies are guilty of crimes against humanity if they continue to dispute what is understood scientifically and to fund contrarians ..." Hansen has repeated his desire to punish deniers more than once.

¹⁵ Reported on the **Nature** blog The Great Beyond: http://blogs.nature.com/news/thegreatbeyond/2008/06/he_wants_you_all_to_sing_along.html

Nobel Prize for chemistry in 1954. After the invention and use of the atomic bomb he became a bomb crusader with naïve views concerning the prospects for world peace. In 1958 he presented a petition signed by 9,000 scientists to the UN protesting nuclear testing. His anti nuclear activities led to receiving the Nobel Peace Prize for 1962, the same prize Al Gore received. In 1970 Pauling wrote a book **Vitamin C and the Common Cold** that unscientifically claimed that the common cold could be prevented or cured by the use of vitamin C. He later claimed that vitamin C was effective in preventing and treating cancer, another unscientific claim. He established an institute that was heavily supported by the world's largest manufacturer of vitamin C.

If southern Florida will be flooded in 500 years by global warming how much are we justified in spending now to prevent it? The flooding of south Florida is often predicted as a consequence of global warming melting the Greenland icecap. As a rough estimate the value of south Florida real estate is \$4 trillion. If you discount this by 6% a year to 500 years in the future¹⁶ the present value is \$0.146 or 15 cents! So according to this analysis we would be justified in spending today not more than 15 cents to prevent southern Florida being flooded in 500 years. That is the power of compound interest. That we are not justified in spending money to prevent some event that may take place in 500 years is not surprising. After all, in only 100 years virtually everything in south Florida will be discarded, demolished or so extensively remodeled as to be effectively replaced.

Considering that Columbus discovered America 500 years ago it is perhaps not surprising that what we do today is not well connected with what happens 500 years in the future. The alarmists recognize that according to normal economic analysis their far future disasters should not influence current policy. That is the reason that they reject economic analysis in favor of emotional posturing.

Why is so much press devoted to speculative climate disaster scenarios? There are plenty of other potential disasters that don't get much attention. The strategic petroleum reserve will only last a few months given any of a number of extremely plausible oil shortage situations. Do we have a national strategic food reserve and what about a world reserve? Are we prepared for a huge earthquake in the Midwest such as occurred in 1811 when the Midwest was inhabited by Indians? Are we prepared for a smallpox epidemic engineered by terrorists? Do we have plans to divert large meteors that could strike the earth from outer space as they have many times in the past? After all, a meteor 8 kilometers in diameter traveling at 30 kilometers per second has enough energy to instantly melt the Greenland ice cap¹⁷, although that would probably be the least of our worries if such a meteor struck the earth. Are we doing enough to keep nuclear weapons out of the hands of terrorists or reckless nations? Are we serious about the flood danger in New Orleans and Sacramento? Golly, are we doing enough to prevent the next ice age?

¹⁶ $4e12 \cdot (1-0.06)^{500} = .146$ Note: Inflation is included in the discount rate.

¹⁷ Assuming a meteor specific gravity of 8.