WHAT WOULD BE THE MAXIMUM RISE IN SEA LEVEL IF ALL THE ICE IN THE ARCTIC REGIONS WHERE TO MELT?

A controversial topic these days deals with global warming and how it may impact the future rise of ocean levels around the world and lead to undesired climate changes detrimental to civilization. Although not yet conclusively proven, the basic idea behind global warming is sound and states essentially that increased CO_2 levels in the atmosphere due to fossil fuel burning can produce a greenhouse effect in our atmosphere leading to an increase in the average world temperatures.

We want here to discuss one of the consequences of such warming , namely, how much will the ocean level rise . We will consider the extreme case of where all ice in the arctic regions melts. Such a scenario is extremely unlikely but will give us an idea on an upper bound on the level rise. Our starting points are the following known facts-

A_{ocean}=Ocean Area=361×10^6 km^2

V_{ocean}=Ocean Volume= 1.3×10^9 km^3

$\rho_{salt\text{-}water}$=Average Salt Water Density=1.03 gm/cm^3=1.03×10^3 kg/m^3

V_{ice}=Total Ice Volume Covering the Polar Regions= 33×10^6 km^3

ρ_{ice}=Density of Ice= 0.92 gm/cm^3=0.92×10^3 kg/m^3

Since most of the ice in the Arctic and Antarctic sits on land and has been formed by thousands of years of snowfall it is almost pure water giving us a melted ice volume of-

$$V_{melted} = 33 \times 10^6 \times 0.92 = 35.87 \text{ million cubic kilometers of fresh water}$$

If this amount of water is added to the ocean of volume of 1.3 billion cubic meters, the average rise in ocean level would be-

$$R = V_{melted}/A_{ocean} = 35.87/361 = 99 \text{ meters or } 325 \text{ feet}$$

This type of ocean level rise would take thousands of years to establish giving man the ability to evacuate low elevation lands such as we have here in Florida. At my home in Gainesville, Florida we won't have to worry about ocean level rise until the level approaches 151 ft (54meters) above present sea level. More likely, in the next hundred years or so, we might expect a rise of a foot or so which will still impose tremendous cost on protecting ocean front land and low lying cities around the world especially during hurricanes(such as Katrina or Sandey). That changes in ocean levels can occur does not seem to be in dispute, it is rather whether the

observed rise in the last hundred years in atmospheric carbon-dioxide content in the atmosphere is a periodic phenomenon or indeed due to the burning of fossil fuels. Ice core samples from arctic glaciers have shown multiple times of high and low temperature periods during the past hundred million years or so. We have ample geological evidence that ocean levels have been both higher and lower during that time. Here in Florida we had much lower sea levels during the last ice age from which we are now just emerging. The evidence are tree stumps which have been found tens of miles out into the Gulf of Mexico from the present day west coast of Florida. One also has found evidence of the reverse, namely, much higher ocean levels in the past indicated by sediment testing. Also we point out that phosphate mining here in Florida was and is along a central ridge running in a north south direction. Such phosphate is formed from seabird guano and these birds would have nested along a shoreline indicating a much higher past ocean level .

A further warming of the earth's should not be viewed all in a negative light. For example an increase in CO_2 is beneficial for plants in that less irrigation is needed and a concomitant rise in temperature makes certain unproductive agricultural lands (including Northern Canada and Siberia) more productive. Also icebergs breaking off of the Antarctic Ice Shelf could be used as a water source for arid regions of the world. A large iceberg might be a cubic mile in volume and contain the equivalent of –

$$(5280)^3 \text{ x } 0.92 \text{ x } 7.48 = 1.01 \text{ trillion gallons of fresh water}$$

Since we have about 7 billion people on earth, such an iceberg would be able to supply each living person with 144 gallons of fresh water. Getting this iceberg to the earth's dryer regions would be a problem but is not insoluble. Towing the iceberg after raping it with a water tight sheet would be a possibility. From the Archimedes Principle we know that an iceberg displaces its own weight by an equivalent weight of seawater, hence the ratio of the volume of the iceberg showing above the waterline to that below the waterline will be only-

$$V_{above}/V_{below}=\rho_{salt\text{-}water}/\ \rho_{ice}-1=1.03/0.92-1=0.119$$

This presents a problem when trying to move the partially melted iceberg through shallow waters. Perhaps pipeline or tanker transport would offer a possibility there.