Evidence of Recent Change

PART A: Melting Glaciers

1: Describe some of the changes that occur on a landscape when a glacier shrinks. Consider the impact on both the land and on living things.

2: How far did the terminus of the Gangotri Glacier recede between 1780 and 2001?

3: How much area did the Gangotri Glacier lose between 1780 and 2001?

4: What is the average rate of recession of the terminus of the Gangotri Glacier? Express your answer in meters/year.

5: Scientists have measured mass balance on more than 300 glaciers since 1946. Based on continuous observations of 40 of those glaciers, the cumulative change in glacier thickness from 1961-2005 was found to be approximately -12 meters. This 12 meter decrease in glacier thickness is equivalent to about 9,000 km$^3$ of meltwater.

   a. Altogether, the world's rivers contain 2120 km$^3$ of water (Source: USGS). How does this compare to the amount of water generated by thinning glaciers between 1961 and 2005?
b. Using the conversion $1 \text{ km}^3 = 2.64 \times 10^{11} \text{ gallons}$, calculate the amount of water in gallons generated by thinning glaciers between 1961 and 2005.

c. It is estimated that the Great Lakes contain about 6 quadrillion ($6 \times 10^{15}$) gallons of water (Source: Great Lakes Information Network). How does the amount of water generated by thinning glaciers compare?

6: Scientists typically calculate glacial mass balance on an annual basis. Explain why it doesn't make sense to perform this calculation more or less often.

7: What impact does climate change (warming or cooling) have on the balance between glacier inputs and outputs?
PART B: Shrinking Sea Ice

1: What is the overall average trend for monthly sea ice volume between 1979 and 2013? Explain.

2: Compare how Arctic sea ice area and volume have changed since 1979:
   a. In 1979, the minimum Arctic sea ice area was approximately 6.4 million km². In 2011, it was 3.6 million km². Calculate the percent change in sea ice area for this time interval.

   How to calculate percent change:
   % change = 100 x (new value - old value)/old value
   • If the result is positive, it is a percentage increase.
   • If the result is negative, it is a percentage decrease.

   b. Arctic sea ice volume was 16,855 km³ in 1979 and 3,261 km³ in 2013. Calculate the percent change in sea ice volume for this time interval.

   c. Based on your answers to a) and b), which has seen a more dramatic change since 1979—minimum Arctic sea ice area or Arctic sea ice volume? Explain what you think this means about the current state of Arctic sea ice and climate.

3: Describe the effect declining ice coverage has on Earth's surface albedo as a function of time.