Student name _____

Student ID _____

GSC 107 – Lab # 3
Calculating sea level changes

Background

Glacial-Interglacial Cycles

Climate-related sea-level changes of the last century are very minor compared with the large changes in sea level that occur as climate oscillates between the cold and warm intervals that are part of the Earth's natural cycle of long-term climate change.

During cold-climate intervals, known as glacial epochs or ice ages, sea level falls because of a shift in the global hydrologic cycle: water is evaporated from the oceans and stored on the continents as large ice sheets and expanded ice caps, ice fields, and mountain glaciers. Global sea level was about 125 meters below today's sea level at the last glacial maximum about 20,000 years ago. As the climate warmed, sea level rose because the melting ice sheets returned their stored water to the world's oceans. During the warmest intervals, called interglacial epochs, sea level is at its highest. Today we are living in the most recent interglacial, an interval that started about 10,000 years ago and is called the Holocene Epoch by geologists.

Sea levels during several previous interglacials were anywhere from 3 to as much as 20 meters higher than current sea level. The precise timing and details of past sea-level history are still being debated, but there is clear evidence for past sea levels significantly higher than current sea level.

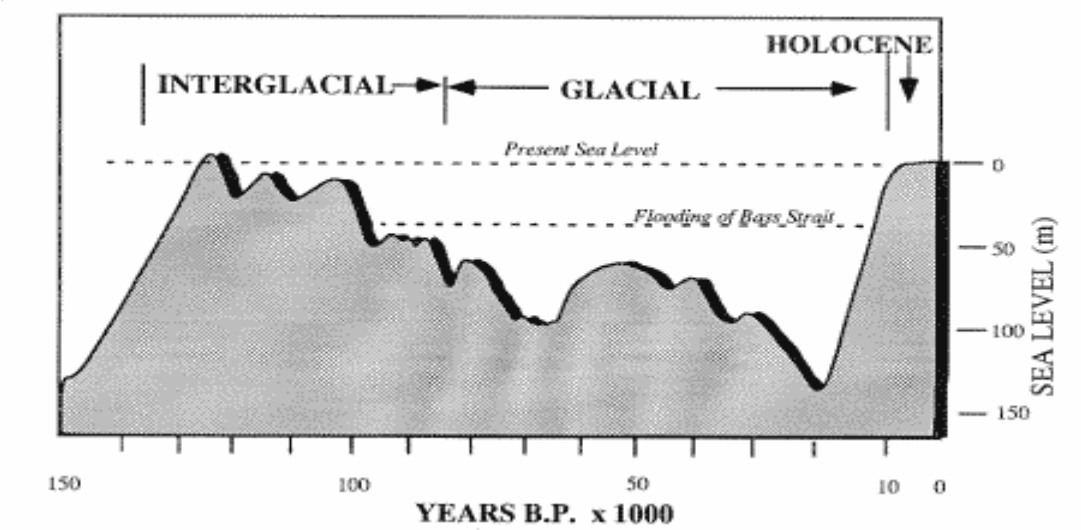


Figure 1: Glacial and interglacial sea level changes during the past 150,000 years.

REMINDER: SHOW UNITS AND YOUR WORK IN ALL PROBLEMS!!

Exercise 1: Maximum sea level rise (10 points)

The present-day sea level reflects a balance between water stored in oceans and on land, mostly in ice sheets. If Earth's climate continues to warm, then the volume of present-day ice sheets will decrease and, as a result, sea level will rise. The two largest ice sheets are on Antarctica and Greenland. Other ice sheets in Alaska, Iceland, and mountainous areas contain only a small fraction of the total stored water on land. In this exercise, you will use simple geographic information (provided below) to calculate the maximum rise of sea level due to melting of all present-day ice sheets.

Geographic information

Earth's surface area	510,000,000 km^2	
Land covered area	150,000,000 km^2	(29%)
Ocean covered area	360,000,000 km^2	(71%)

Antarctica
- Area: 14,000,000 km^2
- Average height of ice cap: 2.1 km

Greenland
- Area: 2,000,000 km^2
- Average height of ice cap: 1.3 km

Other ice sheets
- Area: 5,000,000 km^2
- Average height of ice cap: 0.1 km

Area of some big nations

Russia	17,100,000 km^2
Canada	10,000,000 km^2
USA	9,600,000 km^2
China	9,600,000 km^2
Brazil	8,500,000 km^2

(i) What volume of water is stored in the Antarctica, Greenland, and other ice sheets? [volume = area x height]. *Make sure to list all 3 areas*. **(3 points).**

(ii) If all the water stored in ice sheets were to melt and flow to the ocean, how much would sea level rise (in meters)? [height = volume / ocean area] **(3 points).**

(iii) A more realistic calculation should take into account that 1/5 of the current exposed land mass will also be covered by ocean (including most of Florida). Taking this information into consideration, will the actual sea level will be higher or lower than you calculated? **Why? (4 points).**

Exercise 2: Ice sheet distribution during the last glacial maxima (LGM) (10 points)

During the last ice-age, sea level dropped as much as 125 m below the present-day level (Figure 1).

The excess water was stored in large ice sheets mostly in the northern hemisphere. **Why? (1 point).**

During that period, the coastline migrated offshore depending on the local bathymetry (under-water topography). Use the bathymetric map below to answer the followings:

How far did the ocean migrate from Miami? **(1 point).**

How far did the Gulf coast migrated from Tampa? **(1 point).**

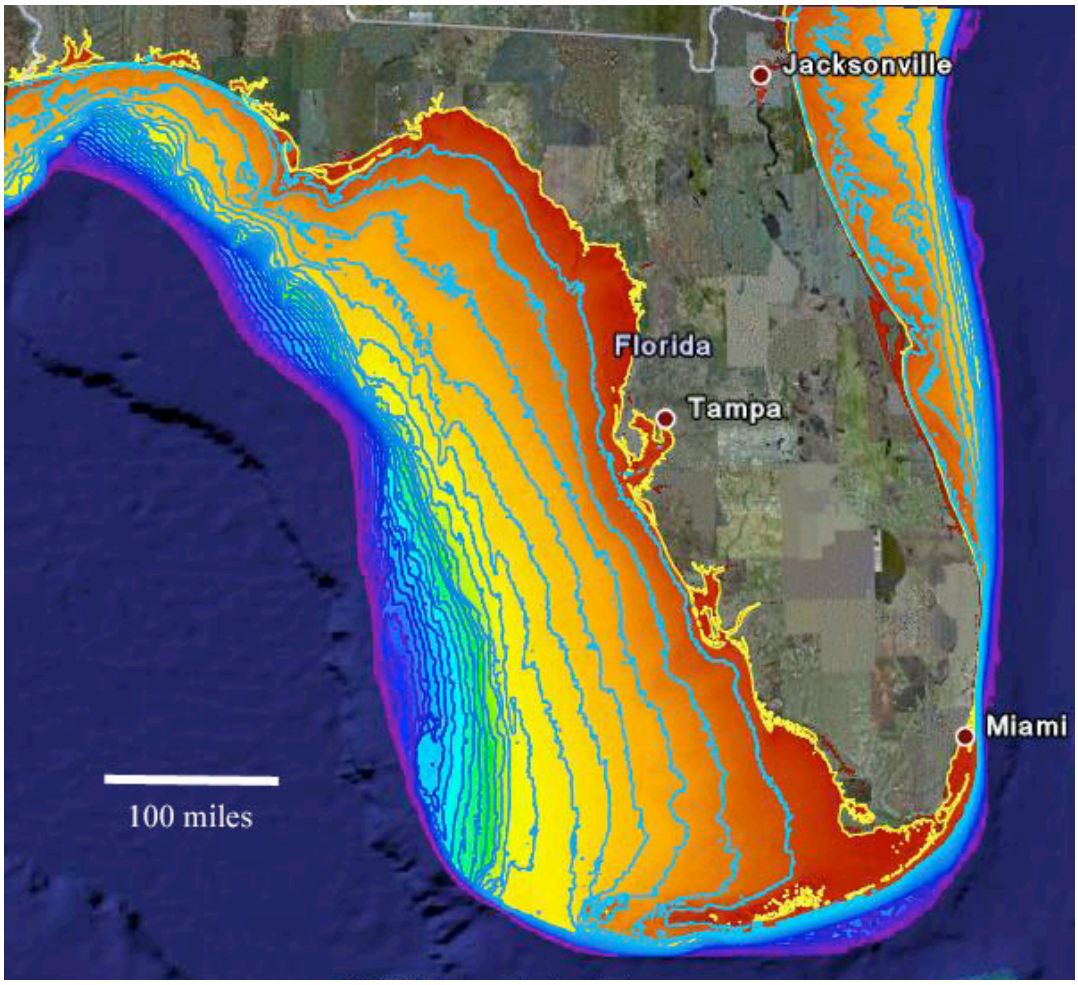


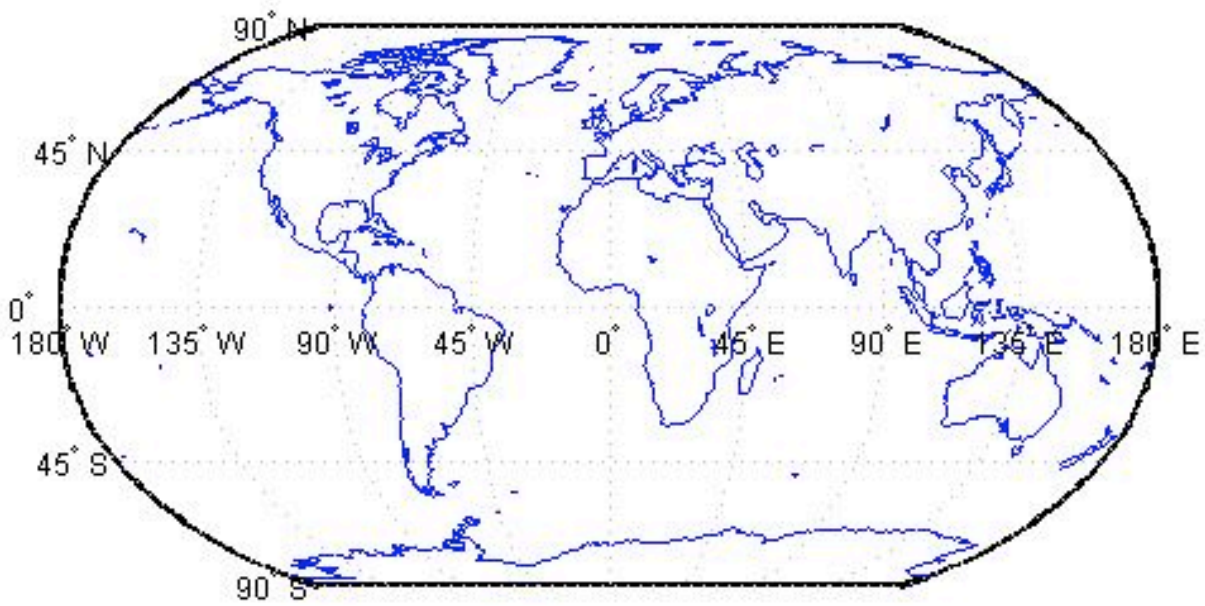
Figure 2: Bathemetric map of the Florida coast (10 meter contours).
Use the above geographical information to calculate the extent of these past ice sheets.

(i) How much additional water volume (with respect to today's level from 1) was stored in ice sheets? [volume = area x height] **(1 points).**

(ii) If all the excess water was stored in Antarctica and Greenland, how high would these ice caps have been (don't forget to add the calculated values to the present-day values)?
[height = volume / area of Antarctica + Greenland] **(2 points).**

(iii) Ice is a weak solid that flows in response to its own load (glaciers flow at a rate of meters per day). As a result, ice sheets cannot sustain ice caps higher that 3.2 km. What will be the left over water volume after both the Antarctic and Greenland ice cap have reached this maximum height? **(2 points).**

(iv) Where was the ice stored (show on the map below)? How much area did it cover assuming all ice caps were 1.2 km high? **(2 points).**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