

Chp 7

1. Earth's seasons are caused by
 - a. The movement of the Sun from North to South of the equator and back again over a year's time
 - b. The distance between Earth and the Sun
 - c. The rate of Earth's movement around the Sun
 - d. The changing position of the tilted Earth with respect to the Sun
 - e. The interaction of the Moon and Sun on Earth's orbit

2. The tilt of Earth's axis is
 - a. Slowly decreasing
 - b. Slowly increasing
 - c. Rapidly decreasing
 - d. Rapidly increasing
 - e. Remaining stable, it is the magnetic pole that is changing.

3. Which of the following statements is correct?
 - a. Tilt causes in-phase changes in insolation for the polar regions of both hemispheres during the months of December-February.
 - b. Tilt causes in-phases changes in insolation for the polar regions of both hemispheres during their respective summer and winter seasons.
 - c. Tilt causes out-of phase changes in insolation for the polar regions in any particular month.
 - d. All of the above are correct.
 - e. Both B and C are correct.

4. Given that the major control on precession-driven changes in insolation is the Earth-Sun distance,
 - a. A precession-cycle insolation maxima will occur everywhere on Earth at the same time
 - b. A precession-cycle insolation maxima would be expected when the Earth-Sun distance is at a maximum
 - c. A precession-cycle insolation maxima would occur in the summer in both the northern and southern hemispheres
 - d. Both A and B
 - e. Both B and C

5. The goal of computer time series analysis is to
 - a. Separate out the different superimposed orbital cycles within a complicated climate record from a geologic archive
 - b. Compensate for the effect of under sampling a geologic archive in climate studies
 - c. Correlate tectonically-driven climate change with orbitally-driven climate change
 - d. Both A and B
 - e. None of the above

6. Spectral analysis
 - a. Requires that the climate record must be at least 4 times longer than the cycled analyzed

- b. Requires at least 2 samples per cycle to avoid the generation of false trends (i.e., aliasing)
- c. Reveals the presence of cycles within complex climate signals
- d. Is a type of time series analysis
- e. All of the above

Chp 8

- 7. The heat capacity of the ocean
 - a. Is greater than the heat capacity of land
 - b. Is less than the heat capacity of land
 - c. Is the same as the heat capacity of land
 - d. Depends on the latitude
 - e. Both A and D
- 8. Monsoon circulation is driven by
 - a. Seasonal changes in insolation
 - b. Differing heat capacities of the land and the ocean
 - c. Upwelling in the coastal ocean
 - d. All of the above
 - e. Both A and B
- 9. Monsoon are stronger
 - a. Where there are large landmasses adjacent to oceans
 - b. Where there are low elevation landmasses adjacent to oceans
 - c. In the southern hemisphere
 - d. All of the above
 - e. Both A and B
- 10. Geologic evidence indicates the Mediterranean Sea acquired a freshwater lid periodically in the last 100,000+ years. What caused this?
 - a. Freshwater was supplied from melting glaciers in the Alps.
 - b. Freshwater was supplied from increased rainfall over the Mediterranean Sea.
 - c. Freshwater was supplied from Nile River outflow, during times of strong summer monsoons over low-latitude North Africa.
 - d. Salt water loss to the North Atlantic occurred when the Straits of Gibraltar periodically opened.
 - e. The cause was catastrophic floods from ice-dam ruptures in the highlands of NE Africa.
- 11. Which of the following shows a 23,000-year cycle?
 - a. Earth's orbital precession
 - b. Sapropel deposition in the Mediterranean Sea
 - c. Freshwater diatom records in cores from the eastern tropical Atlantic
 - d. Marine planktic foraminifera from the eastern equatorial Atlantic
 - e. All of the above

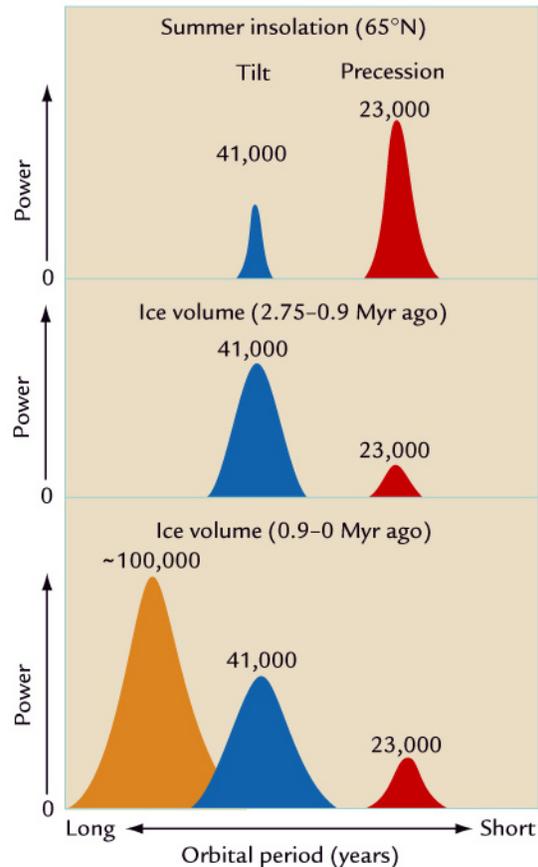
12. Which of the following explains the peak development of summer monsoons in the northern hemisphere at the 23,000-year cycle occurring in July?
- This is the hottest midsummer month, and the land-sea differential heating should be the greatest at this time.
 - The true effects of the insolation forcing peak at the June 21 summer solstice are retarded by the climatic cooling effects of ice sheets in the northern hemisphere.
 - The true effects of the insolation forcing peak at the June 21 summer solstice are retarded by the control of latent heat in the tropical oceans.
 - Each of the above hypotheses is possible, but still needs to be tested.
 - None of the above is a possible explanation.
13. Orbital tuning
- Is a means of dating sediments based on the relationship between astronomically calculated insolation changes and monsoon responses measured in sediments
 - Requires no independent age-depth markers in the sediment sequence
 - Is most easily applied to river sediment sequences
 - All of the above
 - Both A and B
14. The 200-Myr-old lake record from the Newark Basin in present-day New Jersey is characterized by
- Varves
 - Evidence for fluctuations in lake depth
 - Dinosaur footprints
 - All of the above
 - Both A and B
15. A distinct difference between the monsoon signature of the recent sediment records near North Africa and the monsoon signature of the 200-Myr-old Pangaeian sediment record is
- Eccentricity-modulated precession cycles of 100,000 and 400,000 years dominate the Pangaeian record, but not that of North Africa
 - Precession periods are slightly shorter in the Pangaeian record than in that of North Africa
 - Insolation changes during winter season seem to be the dominant control on monsoon strength in the Pangaeian record, unlike North Africa
 - There are no distinct differences between these two records, since they both show changes in monsoon circulation over time
 - Both A and B

Chp 9

16. Where do continental ice sheets exist today?
- In the central Arctic
 - On Antarctica
 - On Greenland
 - Both A and B
 - Both B and C

17. When Earth's tilt is small
- There will be minimum summer insolation in the northern hemisphere
 - There will be minimum summer insolation in the southern hemisphere
 - Ice sheets should grow in the Northern Hemisphere according to the Milankovitch theory
 - All of the above
 - Both A and C
18. What condition drives the equilibrium line *north* in the two-dimensional numerical models of northern hemisphere ice sheet behavior?
- High values of summer insolation
 - Low values of summer insolation
 - High values of winter insolation
 - Low values of winter insolation
 - None of the above
19. The long-term relationship between insolation and ice volume is characterized by a
- Maximum in ice volume occurring at the same time as the minimum in summer insolation
 - Maximum in ice volume occurring at the time as the maximum in summer insolation
 - Maximum ice volume occurring several thousand years after the minimum in summer insolation
 - Maximum ice volume occurring several thousand years before the minimum in summer insolation
 - Maximum ice volume occurring several thousand years after the maximum in summer insolation
20. How does bedrock respond to a heavy ice load?
- It does not respond at all since the density of rock is much greater than the density of ice.
 - It responds at a constant rate over time.
 - It responds with immediate elastic sinking.
 - It responds with gradual viscous sinking.
 - Both C and D are correct.
21. How does the delay in bedrock response to ice loading serve as climate feedback?
- It serves as a negative feedback, muting the effects of insolation-controlled ice volume changes over time.
 - It serves as a negative feedback because any bedrock sinking will cause ice sheets to exist at lower, warmer elevations, causing ice sheets to shrink.
 - It serves as a positive feedback because the delay in bedrock sinking means ice sheets stay at higher, colder elevations where they can grow faster.
 - It controls the amount of insolation received at Earth's surface.
 - Both A and B are correct.
22. What would cause ice to advance southward in the high northern latitudes?
- A southward shift in the climate point would cause it.

- b. Internal flow from the area of ice accumulation in the north carries ice to the south.
 - c. Bedrock depression would cause it.
 - d. All of the above are correct.
 - e. Both A and B are correct.
23. How does ice move?
- a. It slips along its base.
 - b. It flows internally from regions of net accumulation to regions of net ablation.
 - c. It flows internally in the low-elevation, warm areas of the ice sheet, but not in the high-elevation, cold areas of the ice sheet.
 - d. Both A and B are correct.
 - e. Both B and C are correct.
24. A positive excursion in $\delta^{18}\text{O}$ of benthic foraminifera can be an indirect indicator of
- a. An increase in sea ice
 - b. warmer temperatures
 - c. An increase in glacial ice volume
 - d. All of the above
 - e. Both A and C
25. $\delta^{18}\text{O}$ changes over the last million years show
- a. Abrupt transitions to glaciations
 - b. Saw-toothed transitions toward interglacials
 - c. A spacing of 10,000 years between successive glaciations
 - d. All of the above
 - e. None of the above
26. Each 10-m change in global sea level results in an isotopic ($\delta^{18}\text{O}$) change of what amount?
- a. 0.1-0.2 ‰
 - b. 0.4-0.5 ‰
 - c. 0.8-1.1 ‰
 - d. 1.5-3.0 ‰
 - e. 3.5-5.0 ‰
27. Examine the following figure and determine which of the statements describes the spectral analysis information shown.



- Summer insolation changes at 65°N are strong at 100,000 years.
- Ice volume changes in the last 0.9 Myr are controlled largely by eccentricity.
- Ice volume changes in the last 2.75 Myr have a stronger obliquity signal than a precession signal.
- All of the above are correct.
- Both A and B are correct.

Chp 10

28. Drilling ice cores

- Is done in the winter season
- Has provided an archive of climate signals of the last several thousand years
- Occurs at the margins of ice sheets so that drilling can penetrate the underlying bedrock
- All of the above
- Both A and B

29. How does ice retain a record of past atmospheric gas composition?

- In trapped air bubbles
- Within the frozen water molecules
- In air trapped at the bedrock-ice interface
- Indirectly through the composition of included volcanic ash layers
- All of the above

30. How do CO₂ oscillations from ice cores compare with changes in ice volume, as recorded by δ¹⁸O records in marine sediments?
- CO₂ is high when ice volume is high.
 - CO₂ is low when ice volume is high.
 - CO₂ lags ice volume by 41,000 years.
 - CO₂ shows small changes at glacial to interglacial transitions.
 - Both B and D are correct.
31. Which isotopic transfer occurs during glaciations?
- ¹²C-enriched organic matter is transferred from land to the ocean.
 - ¹³C-enriched organic matter is transferred from land to the ocean.
 - ¹⁶O-enriched water vapor is transferred from the land to the ocean.
 - Both A and B are correct.
 - Both B and C are correct.
32. The most negative deep ocean δ¹³C values
- Are spaced at intervals close to 100,000 years during the last 0.9 Myr
 - Are spaced at intervals close to 41,000 years prior to 0.9 Myr ago
 - Occur during glacial maximums
 - All of the above
 - Both A and B
33. For the biological carbon pump reduces atmospheric CO₂
- More nutrients must be available in the surface waters
 - The rate of photosynthesis in the surface waters must increase
 - The rate of precipitation over the oceans must increase
 - All of the above
 - Both A and B
34. Regional δ¹³C variations in the ocean
- Result from regional differences in the degree of photosynthesis
 - Show a distinct contrast between high-δ¹³C waters formed in the North Atlantic and low-δ¹³C waters formed around Antarctica
 - Show a shallowing of northern-sourced deep waters (i.e., North Atlantic deep water) during the last glacial maximum
 - Both A and B
 - All of the above
35. How could changes in the pattern of deep-water circulation have helped to drawdown CO₂ concentrations in the atmosphere?
- Stronger input of North Atlantic-sourced waters during glaciations could have enhanced the biological pump.
 - An expanded area of corrosive Antarctic-sourced waters during glaciations could have changed the carbonate chemistry of the oceans such that more CO₃²⁻ was available to react with CO₂.
 - Increased exchange of deep water between the Arctic and the North Pacific during glaciations could have increased nutrient-supply to the North Pacific, enhancing the biological pump.

- d. All of the above are correct.
 - e. Both A and B are correct.
36. Where is most natural methane produced?
- a. In the tropics
 - b. In the circum-Arctic
 - c. In wetlands
 - d. In anoxic environments
 - e. All of the above
37. Greenhouse gas variations at the 23,000-year precession cycle
- a. Serve as an ice sheet forcing
 - b. Serve as an ice sheet feedback
 - c. Lag northern hemisphere July summer insolation variation by several thousand years
 - d. Both B and C

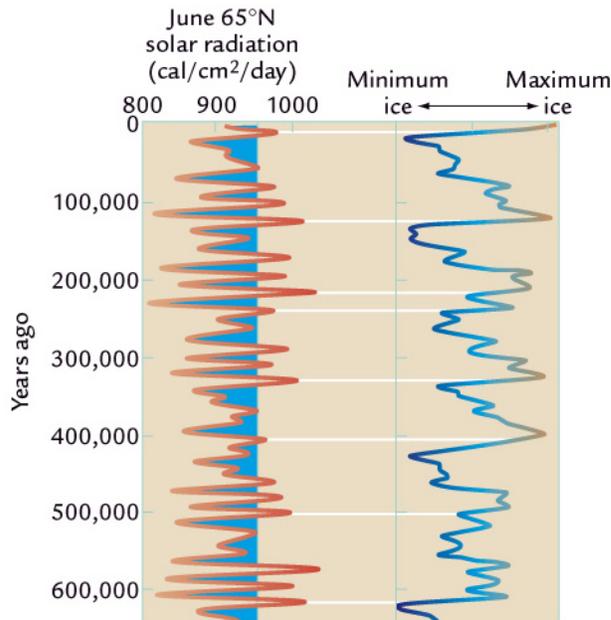
Chp 11

38. Spectral analyses of summer insolation at 65°N shows summer insolation is
- a. strongest at the 23,000-year precession period
 - b. strongest at the 41,000-year obliquity period
 - c. strongest at the 100,000-year eccentricity period
 - d. equally strong at the 41,000-year period and the 23,000 year period
 - e. equally strong at the 41,000-year period and the 100,000 year period
39. How does a shorter-than-normal length of the summer season potentially explain the mismatch between the strengths of the insolation and ice-sheet power spectra between 2.75 and 0.9 Ma?
- a. It could cancel out the intensity of summer insolation at the 23,000-year precession cycle.
 - b. It could eliminate the large variations in amplitude of insolation at the 23,000-year precession cycle.
 - c. It could increase the intensity of summer insolation at the 41,000-year obliquity cycle.
 - d. All of the above are correct.
 - e. Both A and B are correct.
40. How does a CO₂ feedback potentially explain the mismatch between the strengths of the 41,000-year insolation and ice sheet power spectra between 2.75 and 0.9 Myr?
- a. It could amplify the ice volume response to insolation forcing at the 41,000-year cycle.
 - b. It could amplify the ice volume response to insolation forcing at the 23,000-year cycle.
 - c. It could diminish the ice volume response to insolation forcing at the 41,000-year cycle.
 - d. It could diminish the ice volume response to insolation forcing at the 23,000-year cycle.
 - e. All of the above are correct.

41. Which of the following explanations for the mismatch between the strengths of the insolation and ice sheet power spectra between 2.75 and 0.9 Myr contains no identified flaws?
- CO₂ feedback contains no flaws.
 - Interhemispheric cancellation contains no flaws.
 - The length of summer season cancellation contains no flaws.
 - All of the above are correct.
 - None of the above is correct.

42. How could ice sheets have controlled CO₂?
- Strong ice sheet-driven winds could transport iron-rich dust to the ocean, enhancing the biological carbon pump.
 - Ice sheet driven-deep water circulation changes could have resulted in a drop of CO₃²⁻ ions concentrations in the south polar ocean, triggering a drawdown of CO₂.
 - Ice sheet driven-cooling of the ocean waters could have increased the solubility of CO₂.
 - All of the above are correct.
 - Both A and C are correct.

43. Examine the following figure to determine which of the interpretations of the insolation and δ¹⁸O data is reasonable.

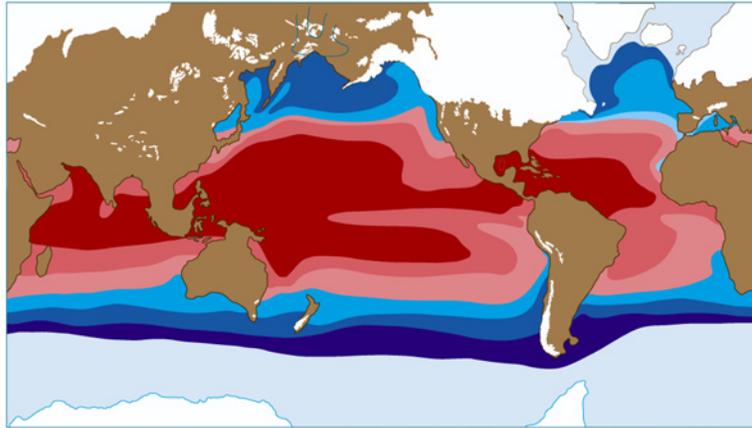


- Insolation changes are dominated by a 23,000-cycle.
 - Eccentricity modulation of the precession cycle result in very strong summer insolation about every 100,000 years.
 - The strongest summer insolation peaks co-occur with rapid deglaciations.
 - All of the above are correct.
 - Both B and C are correct.
44. Why are tectonic-scale changes inadequate for producing a 100,000-year *resonant response* in the climate system during the last several Myr?

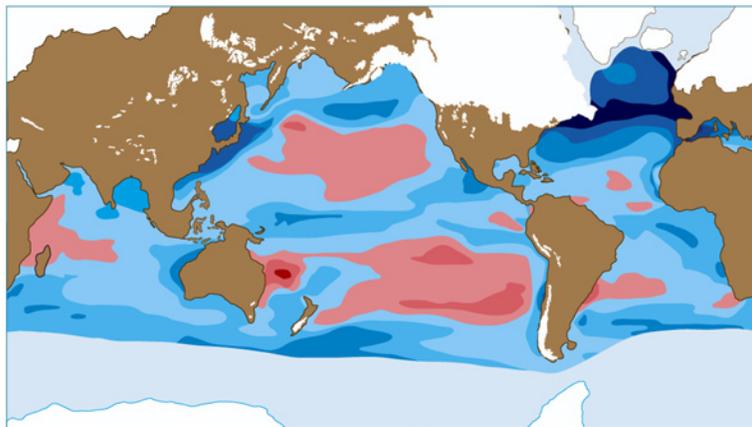
- a. The rates of plate motion are too slow.
 - b. The rate of mountain building is too fast.
 - c. The rate of mountain erosion is too fast.
 - d. Both B and C are correct.
 - e. All of the above are correct.
45. How might ice sheets prior to ~1 Myr differ from those existing after 1 Myr?
- a. Ice sheets prior to 1 Myr were thicker.
 - b. Ice sheets prior to 1 Myr were flowed more slower at their bases.
 - c. Ice sheets prior to 1 Myr overrode more soft sediment and less bare bedrock.
 - d. All of the above are correct.
 - e. Both A and B are correct.
46. What is a glacial termination?
- a. An interglacial
 - b. Any deglaciation
 - c. Deglaciations that occur at the end of a long, irregular (saw-toothed) cooling phase
 - d. Where the glacier meets the sea
 - e. Global warming

Chp 12

47. Which of the following climatic conditions characterized the last glacial maximum?
- a. Ice sheets 10 km thick covered Canada.
 - b. The global sea level was 110-125 m lower than today.
 - c. The climate was humid and there was high precipitation.
 - d. All of the above are correct.
 - e. Both A and B are correct.
48. At the last glacial maximum,
- a. Summer and winter insolation levels were similar to those of today
 - b. Summer and winter insolation levels were both greater than today
 - c. Summer insolation was greater, and winter insolation was less than today
 - d. Summer insolation was less, and winter insolation was greater than today
 - e. Summer and winter insolation levels were the opposite to those of today
49. What percent of Earth's continental area was covered by ice at the last glacial maximum according to the CLIMAP reconstruction?
- a. 1%
 - b. 7%
 - c. 16%
 - d. 25%
 - e. 49%
50. Examine the following figure and determine which of the following statements correctly describes the CLIMAP reconstruction data for the last glacial maximum (LGM) shown in the figure.



A August ocean temperature 21,000 years ago (°C) ■ < 5 ■ 5-10 ■ 10-15 ■ 15-20 ■ 20-25 ■ >25



B August ocean temperature change (°C) Cooling ■ >8 ■ 6-8 ■ 4-6 ■ 2-4 ■ 0-2
Warming ■ 0-2 ■ >2

- Equatorial surface ocean temperatures were cooler at the LGM than they are today.
- Surface ocean temperatures were colder in the North Atlantic at the LGM than they are today.
- Continental ice sheets were extensive in the northern hemisphere, but were not present in the southern hemisphere.
- All of the above are correct.
- Both A and B are correct.

51. What evidence supports a relatively thin Laurentide ice sheet at the last glacial maximum?

- The distribution of bedrock compared to that of soft sediment in the known glaciated areas of North America
- Estimates of the amount of bedrock rebound
- Low-end estimates of sea level change
- All of the above
- Both A and B

52. What is the broad scientific benefit of projects like COHMAP and CLIMAP?

- Scientific problems can be better addressed in an interdisciplinary effort.
- Large synthesis datasets can be generated by collaborative teamwork.

- c. Only the scientists involved will have access to the results of the project investigation.
 - d. All of the above are benefits.
 - e. Both A and B are benefits.
53. Model simulations of the last glacial maximum indicate that
- a. A single jet stream shifted north, almost crossing the North Pole
 - b. A single jet stream shifted south, flowing over the American southeast
 - c. The jet stream split into a northern branch above the northern edge of the ice sheet and a southern branch above the American southwest
 - d. The jet stream split into a eastern branch along the Appalachian mountains and a western branch along the Cascades
 - e. The jet stream reversed direction, flowing out of the Eurasian Arctic and then west toward the American southeast
54. How was climate different from today's climate in the American southwest during the last glacial maximum?
- a. It was much wetter than today and contained many basin-filled lakes.
 - b. It was even hotter and drier than today.
 - c. It was no different than today because it was so far from the ice margin.
 - d. It was covered by the Cordilleran ice sheet.
 - e. It was much windier than today because the jet stream was displaced to the south.
55. What disagreements currently exist between climate model simulations and regional climate archive data for the last glacial maximum?
- a. Simulations indicate that northern Asia was covered by deciduous forests, but archive data indicates it was actually permafrost and tundra.
 - b. Simulations indicate Europe was covered by tundra and grasses, but archive data indicate it was covered deciduous trees.
 - c. Simulations indicate the American southeast had a wide distribution of deciduous trees, but archive data indicates the distribution of these trees was very sparse.
 - d. All of the above are correct.
 - e. Both A and B are correct.