Climate During and After Glacial Maximum 21,000 years ago

- Summer Insolation started about like today, rises to a maximum 10 kya and falls back to the same level
- Ice Sheets melt between 17 kya and 6 kya
  - While present they keep Earth somewhat cooler
  - Once gone things warm quickly for awhile, insolation still high
  - Then insolation decrease causes a little cooling
- Greenhouse gases rise dramatically as Ice Sheets melted
Tracking Ice Sheet Melting

- Tracking recessional moraines
  - Doesn’t move northward soon enough – dramatic melting occurs between 17 kya and 13 kya, but southern edge not moving much
- Thinning and sliding as climate warms
- Area doesn’t change, but volume does
- Tracking sea level rise is more accurate
  - Corals show dramatic change during these time intervals
Details of Melting Time

- Extreme Melt Pulses require more than insolation
  - Positive Feedback mechanism
    - GHGs
    - Ice Sheets sliding into warm climates
- Mid-Deglacial Cooling (Younger Dryas)
  - 13 kya – 11.7 kya
  - Evidence in sea level changes – rise slows dramatically
  - Pollens
    - Dryas (and others) move back toward the south
Younger Dryas Event
Did the proglacial lake, Lake Agassiz, cause the Younger Dryas event?

- Proglacial lakes followed the ice sheet edge while slow isostatic rebound occurred.
- Lake overflowed and dumped very cold water into oceans.
- Did that cause a global cooling event? – The Younger Dryas
Glacial Lake Missoula and Flooding of the Walla Walla Valley

“Little Grand Canyon”
Touchet Beds – floods deposite
Flooded Continental Shelves

Changes Migration Patterns
Tropical Climate Change

• Tropical regions not directly affected by glaciers or deglaciation
• Affected by strong summer insolation
  • Insolation peak 10 kya resulted in strong N. Hemisphere monsoons
• Today’s desert Middle East was lush from monsoon rains
• The cradle of western civilization
Plant induced positive feedback

• 10,000 years ago plants extended farther north than models predict
• Must have been a positive feedback mechanism
  • Evapotranspiration – plants put moisture into the air
  • More moisture in the air – leads to more rain fall – more plants
Tropics Following Insolation Max

- Insolation maximum occurred 10,000 years ago
- Decreasing insolation results in weakening monsoons
- Middle East moves toward the desert conditions we know today
- Transition was not smooth – just like the melting of ice sheets
  - Lots of feedbacks results in variations more complex than the simple and smooth insolation decrease.
  - Data from dramatic lake level variations

10,000 years ago (similar to this)  

Today
Northern Hemisphere after melting

• Ice Sheets at today’s level by 6000 years ago
  • (4000 years after insolation max – close to a ¼ cycle lag – Milankovitch prediction
• Insolation then much greater than today and the ice chill effect is over
  • Plants rapidly migrate northward
  • Reach northward 300 km farther than today by 5000 years ago
    • Again the plant positive feedback probably drove them northward
• No-Analog vegetation
  • Species grew together then that are far removed from each other today
    • Cause, some species migrate more quickly than others
    • Makes for a mixed-up vegetation time when change is happening rapidly
No Analog Vegetation
The Future

• Monsoons will begin to strengthen again soon
  • Controlled by 23,000 year precession cycle
  • Last maximum was about 10,000 years ago
  • Currently we are near the low point in this cycle

• Interglacial periods only last about 10,000 years
  • Based on data from the last 600,000 years
  • We began this interglacial somewhere between 6 and 10 k years ago
  • Prediction – new ice sheets should begin to form in the not to distance future

• 10,000 into the future
  • Minimum tilt reached – cooler poles
  • But, northern hemisphere will have high summer insolation due to precession cycle
  • Net affect???????????? – pulled in opposite direction
  • Could these two cancel and we skip a glacial period?
    • Has never happened since we entered this Ice House world 2.75 mya
    • Himalayas still rising and weathering, so global cooling still in effect

• An now what about human caused changes????????????