MAR 110 Lecture #36
REVIEW Section 3

MAR 110
Natural Hazards & the Ocean

Final Examination Format

Wednesday December 17, 2007
DION Room 110

PART 1 - Term/Definition Matching (20 points)
PART 2 – Multiple Choice (50 points)
PART 3 – Short Answers (30 points)

FINAL EXAM STUDY GUIDELINES

1. Know correct answers to ALL previous exams!
2. Know the “Essential” Term definitions;
3. Focus on Review Session material;
4. Understand the details of the “Underlying Principles”;
5. Know which “Underlying Principles” apply to each the Review Session “HAZARDS” and why.
Climate Change-Related Hazards

**ENSO**
- flooding
- drought
- intense winters
- economic disasters

**Global Cooling**
- ice ages
- abrupt climate change

**Global Warming**
- climate zone shift
- ice melting
- sea level rise

Underlying Principles: Climate Change

- Complex Atmosphere-Ocean Interactions
- Global Heat Budget: **Warming & Cooling**
- Role of Ocean **Thermohaline Circulation**
- Long-Term, Short-Term, and Abrupt Changes
The Earth's Climate System is a Complex System

Imbalances in the Heat Budget CAUSE Climate Change
Increases in Greenhouse Gasses

Decrease OUTGOING Infrared Radiation
Increase Warming

Reflection depends on Albedo

REFLECTION INCREASES → Cooling

Stratospheric Volcano Ash decreases solar radiation → Cooling

Greenhouse Warming Effect
Climate Change due to Oceanic *Thermohaline* Circulation CHANGES

A Complex Atmosphere-Ocean Interaction

...with a range of time-scales

HAZARD : Short-Term Climate Change

**ENSO** Human Consequences

Floods & Droughts

*Left:* Flooded area in Bangladesh as a result of the 1998 El Niño event. (Photo courtesy of Penny Tweddle/Panos Pictures/London)  
*Right:* Bush fire in Australia as a result of the 1998 El Niño event. (Photo courtesy of Fred Haegemans/Panos Pictures/London)
Climate Change Time Scales: 3 - 7yr ENSO

<table>
<thead>
<tr>
<th>Solar variation</th>
<th>Plate tectonics</th>
<th>Orbital variations</th>
<th>Thermohaline ocean circulation</th>
<th>Changes Solar cycle</th>
<th>ENSO volcanism</th>
<th>Seasonal cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 million</td>
<td>10 m</td>
<td>1 m</td>
<td>10,000</td>
<td>1,000</td>
<td>100</td>
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ENSO Events affect Winter Climate in North America
How Could Such Abrupt Changes Occur?

.......PERHAPS CHANGES IN THE CONVEYOR BELT!
HAZARD: Abrupt Cooling

Abrupt Change from Medieval Warm Period To the Little Ice Age

Conveyor Belt “ON”

Conveyor Belt “OFF”
Two Modes of the Earth’s Climate System
Conveyor Belt – ON
Conveyor Belt – OFF

Perhaps a Delicate Balance

Question ??????
Can We Predict the Switch Between Modes?

WHY DID THE EARTH COOL for 100,000 years before the last major glaciation - 20,000 BP ?
We do not know!

WHY DID THE EARTH start WARMING 20,000 BP?
We do not know!
HAZARD: Anthropogenic Climate Change

Two Facts!

Global Temperatures
Warmer than previous 1000 years
Atmospheric CO₂
Higher than previous 600,000 years

Are These Facts Related?

CARBON DIOXIDE versus TEMPERATURE data

150,000 Years of Ice Core Data
CO₂ and Temperature have been tracking each other

WHAT IS CAUSE and WHAT IS EFFECT?
HAZARD: Oceanic Acidification

Ocean Uptake of ANTHROPOGENIC CO₂

The Arctic is Warming Faster!
HAZARD: Polar Ice Melting

Past 10 years Sea Level Rise

Twice as fast!

HAZARD: Sea level Rise

Past 20,000 years Sea Level Rise

Past 10 years

Sea Level Rise

Twice as fast!
Sea Level Rise Past Present Future

NEW YORK Future?

20,000 Years Ago

Worst Case Scenario

HAZARD: MORE EXTREME Weather!

FLORIDA looked quite different 20,000 years ago, during a late ice age. At that time, vast amounts of water remained locked in continental ice sheets so that the sea level was nearly 130 meters lower than today (600 ft). As the ice melted, the coastlines oriented inland to their present positions. (Dark line.) Future rising of sea in New Orleans may pose same sea level as additional five meters, inundating large areas (bottom).