Overview

• Causes of Climate Change
• Mitigation of Greenhouse Gases
• Implications of Climate Change
  – Potential Impacts
  – Uncertainty
  – Vulnerability Analysis
• Challenges for Hydrologists
Greenhouse Gases & Climate Change

**Figure 3**

**The Greenhouse Effect**

NATURAL GREENHOUSE EFFECT

The greenhouse effect is a natural warming process. Carbon dioxide (CO₂) and certain other gases are always present in the atmosphere. These gases create a warming effect that has some similarity to the warming inside a greenhouse, hence the name "greenhouse effect."

ENHANCED GREENHOUSE EFFECT

Increasing the amount of greenhouse gases intensifies the greenhouse effect. This side of the globe simulates conditions today, roughly two centuries after the Industrial Revolution began.

Illustration of the greenhouse effect (courtesy of the Marlin Koshland Science Museum of the National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ☀️ is absorbed and converted to heat, which warms the surface. The surface 🌋 emits heat to the atmosphere, where some of it 🌋 is absorbed by greenhouse gases and 🌋 is re-emitted toward the surface. Some of this heat is not trapped by greenhouse gases and 🌋 escapes into space. Human activities that emit additional greenhouse gases to the atmosphere 🌋 increase the amount of heat that gets absorbed before escaping to space, thus enhancing the greenhouse effect and amplifying the warming of the earth.

**Figure 1: Trends in Atmospheric concentrations of GHG and Sulfate Aerosols: 1000 – 2000 AD**

**Indicators of the human influence on the atmosphere during the Industrial era**

- Carbon Dioxide concentration
- Nitrous Oxide concentration
- Methane concentration
- Sulfate aerosols deposited in Greenland ice

Steep rise in GHG Concentrations from 1800 - 2000

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Source Categories

Broward County’s Community-wide GHG emissions inventory captures emissions from all community-related activities.

- Residential Buildings
- Commercial Buildings
- Industrial Buildings
- Transportation
- Waste
- Aircraft
We need to understand the source of greenhouse gas emissions to effectively mitigate the causes of climate change.

Broward County Climate Change Policy

• Adopted a Resolution to Reduce Greenhouse Gases and support the U.S. Mayors' Climate Protection Agreement
  – Short term Goal: 7% below 1990 levels by 2012
  – Long term Goal: 80% below 1990 levels by 2050

• Adoption of Broward County Government Operations Climate Change Report
  – GOAL: 7 percent below 1997 levels by 2015
Call to Action - Mitigation

- Reduce of greenhouse gas emissions 7% below 1990 levels by 2012, 80% by 2050:
  - improving and promoting mass transit;
  - encouraging alternative fuel vehicles;
  - reducing energy use through conservation;
  - increasing use of renewable energy sources (e.g. solar and wind power); and
  - Reducing solid waste generation (1.64 tons/person/yr) especially through recycling and source reduction.

Engineering Societies Agree on Climate Change Action

Three of the world's largest civil engineering societies, including ASCE, have signed a protocol calling for "substantial reductions in greenhouse gas emissions ... to reduce the risk of climate change."

Climate change will continue even as we slow its momentum through mitigation.
Climate Change Impacts in Southeast Florida

- Increasing Temp (3 to 10°F) by 2100
- Increasing occurrence of extreme weather
  - hotter summers
  - drier droughts
  - wetter rainy seasons
- Change in the growing season
- Sea level rise (2-5 feet) by 2100
- Potential change in the frequency and intensity of tropical storms

Local Impacts From Climate Change

From 60 days >90°F in the past to 180 days in the future.
Local Impacts From Climate Change

Sea Level Rise Implications for SE Florida

- Saltwater intrusion into our aquifer
- Drainage and flood control compromised
- Impacts to public and private infrastructure
- Beach erosion
- Impacts to coral reefs
- Impacts to Everglades

Movement of 250 mg/L Salt Front with Varying Sea Level Rise Estimates
Factors Affecting Sea Level Change

A. Components of Change

a. Water-related
   i. Thermal Expansion of sea water
   ii. Volume increase via
      a. ice sheet melting and
      b. land water storage change e.g. glaciers

b. Land-related
   i. Erosion
   ii. Land subsidence and uplift
   iii. Glacial rebound
   iv. Tectonics

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Figure 1. Time series of ice mass changes for the Greenland Ice Sheet estimated from GRACE monthly mass solutions for the period from April 2002 to February 2009. Unfiltered data are blue crosses. Data filtered for the seasonal dependence using a 13-month window are shown as red crosses. The best-fitting quadratic trend is shown (green line). The GRACE data have been corrected for leakage and GIA.


Demonstrates that the mass loss of the Greenland Ice Sheet is accelerating based on time-variable gravity measurements taken from April 2002 through February 2009.
Factors Affecting Sea Level Change

A. Components of Change (cont)

  c. Earth-related
     a. Albedo
     b. Gravity*
     c. Rotational effects*

* Result in non-uniform distribution of sea-level rise
Projection Concerns

1. Positive environmental feedbacks
2. Greater pace of ice melting than previously predicted
3. Drawbacks in the current models
4. Global scale models which cannot reflect local impacts
5. Assumptions of eustatic change
6. Predictions if no change in global warming occurs - Unclear if current impact is reversible within generational time-scales

UNDERSTANDING OUR VULNERABILITIES

At Risk in Broward:
- 1934 households (4151 residents)
- 182 business (1812 employees)
- Property worth ~ $469M
- Library/park/natural area
- 4 major roads including:
  Hollywood Blvd
  Ocean Dr / A1A
  Dania Beach Blvd
  Sheridan St

LEGEND

- Broward County Salinity Control Structures
- General area directly affected by tides
- Area at Risk
Sea level rise is based on additional water above the mean higher high water (MHHW) value. MHHW is defined as the average of the higher high water height of each tidal day. MHHW was calculated from tidal station data along the coast of Broward County during the 1983-2001 epoch and represents approximately 6 inches of elevation on the LiDAR. This value was provided by NOAA Tide and Currents.

LiDAR point elevation error: +/- 0.21 feet (2.52 inches)
LiDAR flown: 2007 - 2008
H: North American Datum 1983 HARN Feet
V: North American Vertical Datum 1988 (NAVD88) Feet
LiDAR point elevations provided by: Florida Division of Emergency Management

As sea level rises in the east, our ability to control flooding in the west will diminish.
Challenges for Hydrologists

A. Developing models which can realistic predict impacts of sea level rise
   a. Uncertainties/Barriers
      i. The past can no longer predict the future
      ii. Sea level rise projection
      iii. Climate/Precipitation predictions
      iv. Economy
         i. Availability of monitoring data
         ii. Costs of sophisticated models

B. Balancing adaptation efforts with the generation of greenhouse gases

Today’s extreme high tide is tomorrow’s average high tide

High Tide on 9/17/09
8 inches higher than normal
The tide breached the seawall on Las Olas Isles
For more information on Broward climate issues and what you can do to reduce greenhouse gas emission

ngassman@broward.org

www.broward.org/climatechange

www.broward.org/gogreen