Water Resources Vulnerability and Adaptation to Climate Change

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Looking Forward – Opportunities for Adapting to Global Warming, MAWWEC  February 27, 2008
Outline of today’s talk...

- What does climate change mean for the Great Lakes Basin?
  - Climate scenarios
  - Hydrology
  - Ecosystems
“Warming of the climate system is unequivocal...” IPCC 2007

- Global annual temperature +0.74°C – 1906 to 2005
- Detecting changes in natural systems: snow, ice, & phenology
- Warming by 2100:
  - globally 1.8°C to 4.0°C depends on emission scenarios (best estimates)
We need to adapt (and mitigate)…

Need to adapt to warming of ~0.4°C next 2 decades

Impact of mitigation felt in future

Business as Usual

Committed warming if GHG held at 2000

Source: IPCC, 2007
www.ipcc.ch
Balanced response to climate change...

- **Mitigation** – reduce emissions & increase sinks of greenhouse gases to halt/prevent climate change
  - change light bulbs, cap & trade program to new energy strategy

- **Adaptation** – respond to impacts of changing climate - moderate harm or exploit beneficial opportunities
  - water conservation to integrated water strategy
Projected changes in climate for the Great Lakes Basin (✓ observed)

**Airshed Effects:**
- ✓ Increase in air temperatures
- ✓ Increase in precipitable water in warmer atmosphere
- • Change in frequency and intensity of storms

**Watershed Effects:**
- ✓ Warmer air temperatures
- • More precipitation (decreases in key seasons)
- ✓ Less winter precipitation as snowfall and more rain
- ✓ Less snowpack
- ✓ More intense precipitation events
- • Increase in evapotranspiration

**Nearshore Effects:**
- ✓ Increase in water temperature
- • Increase in evaporation

**Inlake Effects:**
- ✓ Increase in water temperature
- • Higher evaporative losses from lakes
- ✓ Less ice cover (shorter duration)
# Great Lakes Basin Climate Change Scenarios:

**temperature (T-°C) & precipitation change (P-% )**

for 2050s relative to 1961-1990

<table>
<thead>
<tr>
<th>GCM</th>
<th>ANNUAL</th>
<th>WINTER (DJF)</th>
<th>SPRING (MAM)</th>
<th>SUMMER (JJA)</th>
<th>FALL (SON)</th>
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<tr>
<td>Warm &amp; Wet</td>
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<td></td>
<td>P +2.84</td>
<td>+5.33</td>
<td>+6.60</td>
<td>+0.10</td>
<td>+1.35</td>
</tr>
</tbody>
</table>
Annual average air temperature (°C)
Base case & 2050s

Source: Croley, GLERL
Annual total precipitation (mm)
Base case & 2050s

Source: Croley, GLERL
# Lake Superior - Hydrologic impacts, 2050s

## Lake Outflow Statistics (m³/s)

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Warm &amp; Dry</th>
<th>Warm &amp; Wet</th>
<th>Warm &amp; Dry</th>
<th>Warm &amp; Wet</th>
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</thead>
<tbody>
<tr>
<td><strong>Annual Mean</strong></td>
<td>2334</td>
<td>1865 (-20%)</td>
<td>2194 (-6%)</td>
<td>1914 (-18%)</td>
<td>2128 (-9%)</td>
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</tbody>
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## Change of Lake Level from Base Case (cm)

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<thead>
<tr>
<th></th>
<th>Annual</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
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<tbody>
<tr>
<td><strong>Annual</strong></td>
<td>-36</td>
<td>-38</td>
<td>-35</td>
<td>-36</td>
<td>-38</td>
</tr>
<tr>
<td><strong>Winter</strong></td>
<td>-20</td>
<td>-21</td>
<td>-18</td>
<td>-36</td>
<td>-21</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td>-33</td>
<td>-36</td>
<td>-32</td>
<td>-30</td>
<td>-34</td>
</tr>
<tr>
<td><strong>Summer</strong></td>
<td>-12</td>
<td>-13</td>
<td>-11</td>
<td>-11</td>
<td>-14</td>
</tr>
<tr>
<td><strong>Autumn</strong></td>
<td>-20</td>
<td>-21</td>
<td>-18</td>
<td>-30</td>
<td>-18</td>
</tr>
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Source: Fay & Fan, Environment Canada
Lake Superior - Water Level Scenarios, 2050s

Water level (m asl)

Source: Fay & Fan, Environment Canada
Lake Superior - Outflow Scenarios, 2050s

Source: Fay & Fan, Environment Canada
Water level decline has many multi-dimensional, interacting effects...

Lower water levels in the Great Lakes - St. Lawrence System

SECTORS IMPACTED

Transportation
Tourism & Recreation
Fisheries
Industry & Energy
Municipalities
Health

POTENTIAL IMPACTS (examples)

Decreased depth of navigation channels, inaccessible docks and harbours
More beaches, aesthetic issues, less access to marinas and lakefront
Loss of species, loss of habitat (e.g. spawning areas), contamination
Less potential for hydropower, less water for industrial operations
Increased water quality problems, potential water supply problems
Increased illness from water contamination and poorer water quality, beach closures

OVERALL RESULT

Supply-demand mismatches and issues of apportionment among:
- sectors
- levels of government
- jurisdictions (e.g. provinces/states, Canada/U.S)
- economic uses and ecosystem needs
- upstream and downstream interests

Source: Lemmen & Warren, 2004
New flooding risks and potential increase in damages ...

- More intense precipitation and winter rain
  - flooding in winter and summer?
- Infrastructure must accommodate higher flows
  - safety and performance issues
- Re-evaluate floodplain management and emergency preparedness
  - more structures and people exposed
Changes in fish & wildlife populations …

- Temperature and precipitation thresholds change
  - Ranges expand north e.g., L. Superior and zebra mussel?

- Poorer water quality – e.g., water temperature & dissolved oxygen

- Changes in food sources (or timing of availability)

- Rare & endangered, endemic & migrating species vulnerable
Infrastructure design needs to incorporate climate change...

- Long life & high value of North American capital stock
- Avoid costly retrofits or underperformance of infrastructure
Climate change is a challenge and an opportunity ...

- Climate is changing
  - Past climate no longer reliable guide to the future
- Many projected impacts more extreme versions of what already experiencing locally
  - Exacerbate local management concerns and affect policy and programs
- How can we “mainstream” climate change information into decision-making?
  - Planning informed/guided by climate scenarios & monitoring
  - “No regrets” adaptations
Overcoming barriers ...

- **We’ll deal with climate change when we see it happening**
  - many impacts of climate change are being observed
  - what are the climate trends in your local area

- **We’ll deal with climate change when you tell us exactly what we need to plan for**
  - challenge of planning with evolving and imperfect information
  - what is the climate sensitivity of your activity/sector/community
  - scenarios used in other aspects of planning – show risks and vulnerability
  - how can you manage/plan to maintain flexibility (flood plain development, water supply)

- **Our decisions based on historical statistics not modelling**
  - need to recognize that past climate no longer reliable guide to future
  - explore implications of climate change scenarios

- **We don’t have time or money to deal with climate change now**
  - climate change influences frequency, intensity, extent and/or magnitude of existing problems
  - hedge against potential impacts and “no regrets” adaptations

Source: Preparing for climate change - Guidebook, 2007