Introduction

Observations

Drivers

Models

Monitoring and Modelling Change:
Great Lakes Water Levels

Andrew Gronewold, Ph.D., P.E.
drew.gronewold@noaa.gov

Great Lakes Environmental Research Laboratory
National Oceanic and Atmospheric Administration
and
Department of Civil and Environmental Engineering
University of Michigan

June 2014
Outline

1. Introduction
Outline

1. Introduction
2. Water level observations
Outline

1. Introduction
2. Water level observations
3. Water level drivers
4. Water level modeling and projections
Outline

1. Introduction
2. Water level observations
3. Water level drivers
4. Water level modeling and projections
Table: Water volume and surface area of Earth's largest (ranked by surface area) fresh surface waters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Surface area</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(km²)</td>
<td>(mi²)</td>
</tr>
<tr>
<td>Michigan–Huron</td>
<td>U.S. and Canada</td>
<td>117,702</td>
<td>45,445</td>
</tr>
<tr>
<td>Superior</td>
<td>U.S. and Canada</td>
<td>82,414</td>
<td>31,820</td>
</tr>
<tr>
<td>Victoria</td>
<td>Multiple</td>
<td>69,485</td>
<td>26,828</td>
</tr>
<tr>
<td>Tanganyika</td>
<td>Multiple</td>
<td>32,893</td>
<td>12,700</td>
</tr>
<tr>
<td>Baikal</td>
<td>Russia</td>
<td>31,500</td>
<td>12,200</td>
</tr>
<tr>
<td>Great Bear Lake</td>
<td>Canada</td>
<td>31,080</td>
<td>12,000</td>
</tr>
<tr>
<td>Malawi</td>
<td>Multiple</td>
<td>30,044</td>
<td>11,600</td>
</tr>
<tr>
<td>Great Slave Lake</td>
<td>Canada</td>
<td>28,930</td>
<td>11,170</td>
</tr>
<tr>
<td>Erie</td>
<td>U.S. and Canada</td>
<td>25,719</td>
<td>9,930</td>
</tr>
<tr>
<td>Winnipeg</td>
<td>Canada</td>
<td>23,553</td>
<td>9,084</td>
</tr>
<tr>
<td>Ontario</td>
<td>U.S. and Canada</td>
<td>19,477</td>
<td>7,520</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Surface area (km²)</th>
<th>Surface area (mi²)</th>
<th>Volume (km³)</th>
<th>Volume (mi³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan–Huron</td>
<td>U.S. and Canada</td>
<td>117,702</td>
<td>45,445</td>
<td>8,458</td>
<td>2,029</td>
</tr>
<tr>
<td>Superior</td>
<td>U.S. and Canada</td>
<td>82,414</td>
<td>31,820</td>
<td>12,100</td>
<td>2,900</td>
</tr>
<tr>
<td>Victoria</td>
<td>Multiple</td>
<td>69,485</td>
<td>26,828</td>
<td>2,750</td>
<td>660</td>
</tr>
<tr>
<td>Tanganyika</td>
<td>Multiple</td>
<td>32,893</td>
<td>12,700</td>
<td>18,900</td>
<td>4,500</td>
</tr>
<tr>
<td>Baikal</td>
<td>Russia</td>
<td>31,500</td>
<td>12,200</td>
<td>23,600</td>
<td>5,700</td>
</tr>
<tr>
<td>Great Bear Lake</td>
<td>Canada</td>
<td>31,080</td>
<td>12,000</td>
<td>2,236</td>
<td>536</td>
</tr>
<tr>
<td>Malawi</td>
<td>Multiple</td>
<td>30,044</td>
<td>11,600</td>
<td>8,400</td>
<td>2,000</td>
</tr>
<tr>
<td>Great Slave Lake</td>
<td>Canada</td>
<td>28,930</td>
<td>11,170</td>
<td>2,090</td>
<td>500</td>
</tr>
<tr>
<td>Erie</td>
<td>U.S. and Canada</td>
<td>25,719</td>
<td>9,930</td>
<td>489</td>
<td>117</td>
</tr>
<tr>
<td>Winnipeg</td>
<td>Canada</td>
<td>23,553</td>
<td>9,084</td>
<td>283</td>
<td>68</td>
</tr>
<tr>
<td>Ontario</td>
<td>U.S. and Canada</td>
<td>19,477</td>
<td>7,520</td>
<td>1,839</td>
<td>393</td>
</tr>
</tbody>
</table>

**Table:** Water volume and surface area of Earth’s largest (ranked by surface area) fresh surface waters.

Introduction

Observations

Drivers

Models

Outline

1. Introduction

2. Water level observations

3. Water level drivers

4. Water level modeling and projections
Introduction
Observations
Drivers
Models
Introduction
Observations
Drivers
Models

Water level dynamics: mid-term
Great Lakes Water Levels
Seasonal dynamics

[Graph showing water levels for Superior, Michigan- Huron, Erie, and Ontario lakes with data from 1961 to 2016.]
Drivers:
Drivers: hydrologic cycle
Drivers: hydrologic cycle

From: USEPA (1990), Great Lakes Atlas.
Drivers: isostatic rebound

From: Mainville and Craymer (2005), GSA Bulletin.
Processes driving long-term levels: massive spatial scale
Processes driving long-term levels: massive spatial scale

Recognize “baseline conditions” and historical context
Processes driving long-term levels: massive spatial scale
Recognize “baseline conditions” and historical context
Maintain, expand, update over-land and over-lake monitoring
Acknowledgements

- USEPA, USGS, USACE, and Environment Canada
Acknowledgements

- USEPA, USGS, USACE, and Environment Canada
- Frank Quinn, Anne Clites, Tim Hunter, Joe Smith
Monitoring and Modelling Change: Great Lakes Water Levels

Andrew Gronewold, Ph.D., P.E.
drew.gronewold@noaa.gov

Great Lakes Environmental Research Laboratory
National Oceanic and Atmospheric Administration
and
Department of Civil and Environmental Engineering
University of Michigan

June 2014