Water: Enough in Indiana

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Will there be enough water in Indiana in the future?
Or will there be too much?
Annual Precipitation
Annual Average Air Temperature

Average Air Temperature (%)
Observed Trends 1916-2007

<table>
<thead>
<tr>
<th>Precipitation (mm/yr)</th>
<th>Max Daily Temp (°C/yr)</th>
<th>Min Daily Temp (°C/yr)</th>
<th>Soil Moisture (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>0.025</td>
<td>0.025</td>
<td>0.024</td>
</tr>
<tr>
<td>3.2</td>
<td>0.020</td>
<td>0.020</td>
<td>0.012</td>
</tr>
<tr>
<td>2.4</td>
<td>0.015</td>
<td>0.015</td>
<td>0.009</td>
</tr>
<tr>
<td>1.6</td>
<td>0.010</td>
<td>0.010</td>
<td>0.006</td>
</tr>
<tr>
<td>0.8</td>
<td>0.005</td>
<td>0.005</td>
<td>0.003</td>
</tr>
<tr>
<td>-0.8</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.003</td>
</tr>
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Mishra and Cherkauer, 2010
Soil Moisture Trends

 › Observed soil moisture trends from 1981 to 2007

 › Wetter annual conditions to the south, less change to the north

 › Spring soil moisture especially important to planting

Mishra, Cherkauer and Shukla, 2009
Soil Frost Trends

- Long-term (1967-2006) trends in soil temperatures indicate warming
- Shorter term observations are more mixed
- Confounded by changes in snow cover
- Spring soil temperatures important for planting

Triangle indicates direction of trend, fill indicates significance

Sinha, Cherkauer and Mishra, 2009
Trends in Drought Severity

- Drought severity and occurrence have generally decreased between 1915 and 2007.
- Of the 7 agricultural droughts that affected the entire growing season, only 1 has occurred since 1950.
- The extent of droughts has also decreased.
- The drought of 1988 reduced corn production by 30%, and was more severe than the 1930 droughts for 5% of the area.

Mishra and Cherkauer, 2010
Increases in Heavy Rainfall Events

Extreme Precipitation Index-IL,IN,MI,MN,NY,OH,PA, WI
(7-day duration, 1-yr recurrence threshold)
Upper White River Watershed
Delineated to USGS Gage Station 03351000 at Nora, Indiana

Watershed Area (USGS) = 1219 square miles
Delineated Area = 1210 square miles

- Upper White River and Branches
- Watershed Boundary
Observed Streamflow Trends
White River at Nora, IN gage station

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Seven Day High Flow</th>
<th>Seven Day Low Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendall's t value</td>
<td>0.0418</td>
<td><strong>0.3797</strong></td>
</tr>
<tr>
<td>Z-Value</td>
<td>0.507</td>
<td><strong>4.6438</strong></td>
</tr>
</tbody>
</table>

Significant trend if Z-Value is greater than Z-Critical (1.96)
What Might Indiana Be Like?

<table>
<thead>
<tr>
<th></th>
<th>2030 summer</th>
<th>2030 winter</th>
<th>2095 summer</th>
<th>2095 winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F</td>
<td>3-4</td>
<td>2</td>
<td>8-10</td>
<td>4-6</td>
</tr>
<tr>
<td>°C</td>
<td>2</td>
<td>1</td>
<td>4-6</td>
<td>3-4</td>
</tr>
</tbody>
</table>

% Increase/Decrease

<table>
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<tr>
<th></th>
<th>2030 summer</th>
<th>2030 winter</th>
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<tbody>
<tr>
<td></td>
<td>-15</td>
<td>----</td>
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<tr>
<td></td>
<td>-10 to -15</td>
<td>5 to 10</td>
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% Increase 24-hour/Multiday precipitation events

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Annual Precipitation

› Some decrease in precipitation in the early part of the century

› By end of century, precipitation mostly increased
Seasonal Precipitation

- Some decrease in precipitation in the early part of the century
- By end of century, precipitation mostly increased
Heavy Rainfall Events (> 2.5 inches)
Northern Indiana and Illinois

Increases of almost 2x under lower emissions and 3x under higher emissions.
Changes to Daily Flows
Wabash River

High-flow Volumes

Low-flow Deficit Volumes

T_qmean

R-B Index (Flashiness)
Water Use by Category

Water Usage: National

Water Usage: Indiana
Water Use in Indiana

- Energy – use of water in power generation
- Industry – use in manufacturing
- Agricultural – use for crop production and golf courses
- Miscellaneous – All other uses
- Public – distribution for use by others
- Rural use – use for livestock and fish

Source: Water Use in Indiana, IDNR, 2013
National Water Withdrawal Rates

EXPLANATION
Water withdrawals, in million gallons per day
- 0 to 2,000
- 2,000 to 5,000
- 5,000 to 10,000
- 10,000 to 20,000
- 20,000 to 46,000

Map showing total withdrawals by state, with states colored according to the range of water withdrawals.
National Water Withdrawal Intensity

EXPLANATION
Water withdrawals, in gallons per day per square mile
- 0 to 60,000
- 60,000 to 120,000
- 120,000 to 150,000
- 150,000 to 220,000
- 220,000 to 330,000

Puerto Rico
U.S. Virgin Islands
National Irrigation Withdrawals

Total withdrawals

EXPLANATION
Water withdrawals, in million gallons per day

- 0 to 200
- 200 to 1,000
- 1,000 to 5,000
- 5,000 to 15,000
- 15,000 to 25,000

West-east division for this report

Puerto Rico U.S. Virgin Islands
Irrigation Use in Indiana
Irrigation Use in Indiana

› Between 2002 and 2008 irrigated acreage in Indiana increased by 29%

› Rate of adoption has increased since 2012 drought

› Conflicts
  – Pumping for irrigation in Jasper County left the town of Parr, IN without water during the summer of 2012
  – Even in the spring of 2013, wells in Benton County went dry due to the installation of a new irrigation well

› Indiana has enough water, but is it in the right place at the right time?
Management

- Management of water resources will become increasingly important
- Indiana’s laws are more reactive than proactive
  - When a supply problem occurs, the source is identified and required to compensate the affected parties
- More states are starting to look at cooperative solutions
  - For example, implementing “unitization” from the oil industry
    - Designate a single “unit operator” who could extract from and develop the reservoir with other parties tapping the non-renewable groundwater resource share
    - Helps slow down the race to the pump
Warning

› Could the Ogallala Aquifer show us the future?
  - In 2000, the aquifer supplied 17 billion gallons of water per day for irrigation
  - This exceeds the renewal rate for most of the aquifer.
  - Since 1950 water in the aquifer has declined
    - *By up to 70 meters*
    - *By about 324 billion cubic meters*
  - The aquifer is being “mined” and will not support continued use at current levels for much longer

› If Indiana can avoid this problem, it can benefit greatly!
Questions?

For more information, check out the Purdue Hydrologic Impacts Group web page: www.agry.purdue.edu/hydrology