Modeling Scenarios of Water Demand and Energy Use in Minnesota Under Climate Change

Or: Water, Water Everywhere???

Yiwen Chiu, Sangwon Suh, Laura Schmitt Olabisi
The Scientific Challenge:

- Few water use and availability models exist at a policy-relevant scale (e.g. state, regional)
- Of these, none involve dynamic interactions between water availability and human use

The Policy Challenge:

- How to plan for a water future that includes multiple co-occurring dynamics (climate change, population growth, energy production growth, biofuel production)
Our Approach

Chiu et al. 2010. The Future of Energy and Minnesota’s Water Resources
Our Approach

Atmospheric Stock
River and Lake stock
Aquifers
TOTAL CONSUMPTION

Process Water
Water Efficiency
Ethanol

Available Corn for Food
<Transport sector>
EtOH export fraction
Gas replacement rate

<cultivated land>
fraction of area for corn
Harvest fraction
Yield
seasonal yield
fraction

<Hargreaves RET>
Woody land Kc
pasture Kc
corn Kc
<hay, pasture, grassland>
<Woody area>
Corn field

<Power Generation Water Withdrawal (sw)>
<Power Generation Water Withdrawal (gw)>
<hydro area>
<mean temperature>
<Hydro area>
<special water use (sw)>
<special water use (gw)>
<Irrigation (sw)>
<Power generation Water Return>
<Power Generation Water (gw)>

Vapor from power industry
direct rain
evaporation rate
<excess wat>
<RAIN>
<pervious lands>
returned water
outflow
sw withdrawal
sw infiltration
<Power Work (sw)>
<EtOH process water (gw)>
<EtOH process water (sw)>

TOTAL CONSUMPTION

Daily time step
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<th>Scenario</th>
<th>Description of assumption</th>
<th>Climate</th>
<th>Population</th>
<th>Ethanol</th>
<th>Power</th>
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Based on IPCC A2 scenario
20% growth in electricity use per person above linear trend
Minnesota produces 12% national demand
20% growth above demographic projections
Results: Water Withdrawal and Population Growth
Results: Water Stress = \frac{\text{Total water withdrawal}}{\text{Total available water}}
Conclusions: Space and time matter for water planning

- Population growth is by far the most important driver of potential future water stress in Minnesota.
- The Twin Cities area will be especially vulnerable to water stress.
- Climate change will likely supply more water to the state, but at the ‘wrong’ time of year (early spring).
- Ethanol production is unlikely to contribute to statewide water stress, but could be significant locally.