Extreme weather: envisioning Ontario agriculture

Scott Mitchell\textsuperscript{1}, Anna Zaytseva\textsuperscript{1}, Dan MacDonald\textsuperscript{2}, and Ruth Waldick\textsuperscript{1,2}

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Purpose -> constraints

• “... create and deliver information about prospective climate extremes that will affect Ontario’s agriculture sector and rural communities. We will develop a decision support model (DSM) to characterize risk and vulnerabilities associated with climate change and extremes in agriculture, allowing users to plan for and mitigate risks by evaluating different adaptation choices.”

• spatial scenario modelling framework – impacts on crops and livestock*
  • map-based, field-level mapping; expectations
  • data realities: weather stations (time), GCM resolution
  • temporal scales at which can say much about future extreme events are hard to translate to impacts to crops and livestock

• use of seasonal, phenology-linked indices with links to specific crops
(some) Issues with existing information

• (as you’ve heard) there are limitations in using limited weather data, or climate model projections, to characterize extreme weather
  • how extremes usually considered? (climate model variability)
  • spatial-temporal resolution issues/discrepancies
  • how are those relevant to farm-scale / local level planning?

• some of the options we’ve considered
  • GCM output: custom downscaling, PCIC downscaling (to station or grid)
  • past weather data: everything available? “cleaned” data?
    • station-based or grid (10 km regular grid used by AAFC, EC)?
  • temporal resolution: aggregate summaries? Daily variability?

• scenarios:
  • GCM: AR4/AR5? All models? Subset?
  • agriculture, demographics, economic (scale)
Why focus on scenarios and phenological impact modelling?

• every GCM model run is a scenario, not a prediction
  • ecosystem response on top of that impacted by range of possible reactions / adaptation from all ecosystem components, including humans

• GCMs lack spatial and temporal detail, **but** there is demand for information relevant to locally evaluating levels of risk and potential tradeoffs
  • finer resolutions (space & time) → assumptions & potentially very high data needs
  • usually can’t confidently fill all those needs, but can explore a likely range, consider sets of likely parameters under future alternate scenarios

• crop modelling typically focuses on yield, using either a process-based approach (high uncertainty in parameterization across large regions) or empirical models (usually assuming stationary conditions)
  • phenological impact modelling allows us to identify times when crops are particularly vulnerable to climatological events, and assign a typical impact to crop yield; concentrate on relative impacts rather than specific physiological processes
Study area: eastern Ontario

Legend
- planted corn or soybeans
- lakes and rivers
- provincial parks, significant forests and wetlands

A. Zaytseva’s DRAFT M.Sc. Thesis (Carleton University).
Indices derived from “just” weather data

• E. Ontario not expected to be a hotspot of weather extremes
  • but types of extremes of particular relevance in “regular” agricultural operations are not necessarily what people first think of as “extreme”

• “standard” indices are available to analyse and compare weather / extremes
  • useful to describe general trends

• some, however, mask processes that are important to agriculture
Why extremes? This is NOT the whole story!

A. Zaytseva’s DRAFT M.Sc. Thesis (Carleton University).
Example: general index relevant to human health

• 3 day periods where $T_{\text{max}} > 32^\circ\text{C}$
Example: extreme index: warm nights

A. Zaytseva’s DRAFT M.Sc. Thesis (Carleton University).
Example: precipitation

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MORE CROP RELEVANT: SEASONAL PHENOLOGY INDICES

- Corn (for example):

<table>
<thead>
<tr>
<th>Index name</th>
<th>Definition</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor seeding conditions</td>
<td>Weekly precipitation 30% greater than weekly mean precipitation (between April 23 and May 20)</td>
<td>weeks/year</td>
</tr>
<tr>
<td>Early flooding</td>
<td>Weekly precipitation 30% greater than weekly mean precipitation with 1 to 780 accumulated CHUs</td>
<td>weeks/year</td>
</tr>
<tr>
<td>Pollination drought</td>
<td>CDD &gt;10 with 1,301 to 1,600 accumulated CHUs</td>
<td>annual occurrence (Yes or No)</td>
</tr>
<tr>
<td>R2 (blister) drought</td>
<td>P&lt;45mm with 1,601 to 1,825 accumulated CHUs</td>
<td>annual occurrence (Yes or No)</td>
</tr>
<tr>
<td>R3 (milk) drought</td>
<td>P&lt;45mm with 1,826 to 2,000 accumulated CHUs</td>
<td>annual occurrence (Yes or No)</td>
</tr>
<tr>
<td>Early killing frost</td>
<td>Tmin &lt;=-2°C with 2,165 to 2,475 accumulated CHUs</td>
<td>days/year</td>
</tr>
<tr>
<td>R4 (dough) drought</td>
<td>P&lt;8mm with 2,001 to 2,165 accumulated CHUs</td>
<td>annual occurrence (Yes or No)</td>
</tr>
<tr>
<td>Fall killing frost</td>
<td>Tmin &lt;=-2°C with 2,476 to 2,600 accumulated CHUs</td>
<td>days/year</td>
</tr>
</tbody>
</table>

A. Zaytseva’s DRAFT M.Sc. Thesis (Carleton University).
Example: poor seeding conditions
Example: early flooding

A. Zaytseva’s DRAFT M.Sc. Thesis (Carleton University).
Example: seed development drought

A. Zaytseva’s DRAFT M.Sc. Thesis (Carleton University).
Example: projected seeding delays

Area "lost" to fallow due to seeding delays

- 2011: 11,000
- 2012: 8,000
- 2013: 6,000
- 2014: 4,000
- 2015: 4,000
- 2016: 2,000
- 2019: 3,000
- 2020: 2,000
Lessons and future considerations:

• crop- and phenology-specific, scenario impact-based approach to extremes allows us to highlight relative risks of “subtle” but agriculturally relevant shifts in climate
  • relevance: impact on farm operations
  • potential to evaluate switching to (or need to develop) different varieties

• scenario modelling: uses field-level decisions but does not rely on needing to confidently parameterize field-level details with a specific “reality”
  • relevant to categories of farming operations as they exist in this region, with real biophysical constraints
  • allows us to manage uncertainty, and concentrate on scenarios that have relevance to adaptation planning
"Scenario-based risk assessment decision support modelling tools for regional climate change and climate extremes, impacts and adaptation in agricultural watersheds" is a project funded by the Ontario Ministry of Agriculture, Food, and Rural Affairs' New Directions Research Program. One of our main objectives is to provide a clearing-house for information and resources that are useful for evaluating climate change in Ontario, starting with our pilot program in eastern Ontario.

Several parallel sub-projects have been launched to help meet our objectives. We have characterized the changing climate in eastern Ontario, with a focus on extreme weather. To help with this, we are developing and evaluating decision support indicators of extreme events to assist managers in making informed decisions.