Accounting for Climate Change Impacts in the Design of Resource Road Crossings

(Webinar #7) Designing Resource Road Stream Crossings Considering Climate Change: Two Case Studies from Coastal B.C.

January 14th, 2021

Lee Deslauriers  Principal and Managing Engineer, StoneCroft Engineering
Matt Kurowski  Research Engineer, FPInnovations

• The session will start at 10:00 PST / 13:00 EST
• All lines will be muted during the presentation
• This webinar will be recorded and posted to FLRNORD website
• Interact! Vote on polls and ask/upvote questions  slido.com event code: fpi

Join at  slido.com #fpi
Small watershed crossings and climate change

- Brian Chow, P.Eng. (Chief Engineer, FLNRORD)
Panel

- Jeremy Fyke, Ph.D. (Canadian Centre for Climate Services)
- Paul Mysak, P.Eng. (Onsite Engineering Ltd.)
- Arelia Schoeneberg, M.Sc. (Pacific Climate Impacts Consortium)
- Kari Tyler, M.Ed. (Pacific Climate Impacts Consortium)
Influence and Contribute to the Presentation!

Step 1 - go to slido.com (on phone or computer)

Step 2 - Joining as a participant?

Anonymous by default

- Vote on live polls
- Ask and upvote questions/comments
Speaking & Login ID Questions/Comments

1. Use WebEx to voice a comment/question

   2. A Menu pops up – click “raise hand”

2. Use WebEx Chat to
   - ask tech support questions
   - comment/question using WebEx login ID (publicly or privately)

   1. Click Participant list

   1. Click Chat Box
• Poll 1!
  – Go to slido.com
  – Event code is “fpi”
Webinar Outline

• (15 min) **Intro + 3 methods that account for climate change impacts in small watershed design floods**
  – Situating 5 publicly available tools (Matt)

• (50 min) **Two case studies (34 km² & 0.3 km² basins)**
  – Design review - (Lee)
  – Outputs from 5 climate tools (Matt)
  – Rationalizing climate impacts for the design (Lee)

• (25 min) **Discussion:**
  – Comments/questions (panelists, attendees)
How are climate projections derived?

• ~40 global climate models (GCMs)
  – ~10 000 km² daily/monthly grids
  – Use physics simulations and historic data as basis for projecting future
  – Each GCM runs many permutations (staring conditions)
  – Significant computations required

• GCMs have baked-in representative concentration pathway (RCPs) for future conditions
  – Best -> worst scenarios for future carbon emissions: 2.6, 4.5, 6.5, 8.5

• Statistical methods can combine GCMs with regional / local data to “downscale” GCMs to higher spatiotemporal resolutions:
  – Canada: daily resolution ~56 km² grid for temperature & precipitation 1950-2100
How are climate projections summarized?

- **Climate indices**: statistical summaries of climate – e.g.
  - maximum consecutive days with no rain
  - daily maximum precipitation in the fall season
  - average number of days/year that reach 20 degrees
  - 5-day daily antecedent rain >15mm

- **Standardized future periods**:
  - Three common periods: near, mid, and far future
  - **2020s** (2010-2039), **2050s** (2040-2069), **2080s** (2070-2099)
How are climate projections made accessible?

• Publicly available climate tools
  – Interactive maps that show – or use – climate index grids with historical and future periods
How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

All precipitation-based
How are climate projections made accessible?

Why not publicly available climate tools?

- Interactive maps that show—or use—climate index grids with historical and future periods

projection

climate tools

climate change tools?
How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Can be used to calculate historic IDF curves

- ClimateBC_v6.20
- PLAN2ADAPT
- IDF_CC Tool 4.0
- COLUMBIA BASIN CLIMATE SOURCE
- PCIC Climate Explorer
- ClimateData.ca
How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show or use climate index grids with historical and future periods

- Not for historic data (only for projections that reference simulated historic data)

**Useful for climate change impacts to snowmelt-dominated peak flows??**
How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods
How are climate projections made accessible?

- Publicly available climate tools
  - Interactive maps that show – or use – climate index grids with historical and future periods

British Columbia

- ClimateBC_v6.20
- PCIC Climate Explorer

Entire Canada

- PLAN2ADAPT
- IDF_CC Tool 4.0
- ClimateData.ca
How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Desktop software

Access via internet browser

- ClimateBC_v6.20
- PLAN2ADAPT
- IDF_CC Tool 4.0
- PCIC Climate Explorer
- ClimateData.ca
How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Access via internet browser

Also access via internet browser – but less features
There is no agreed upon method

• Especially for small watersheds
• This webinar **will not provide** THE answer for how to take climate change into account in design flood calculations
• This webinar **will provide** a way forward by exploring different options and discussing options
3 approaches that account for climate change

1. **Use IDF_CC while being aware of its methods, limitations, and assumptions**
   - Uses climate indices within background calculations and outputs IDF curves at point locations with high temporal resolution (down to 5 minutes)
   - Professional guidance: be aware of projections of sub-daily values as this assumes stationarity of the relationships between daily and sub-daily events – especially when 30+ years in future (Engineers and Geoscientists BC, 2018)

2. **Use climate index-based climate tools alongside your professional judgement**
   - Professional judgement must i) select a climate index related to local extreme flooding, and ii) assume how the daily (or greater) resolution of the climate index relates to finer temporal resolution required for a local scale
   - Professional guidance does not outline this approach explicitly, but has advice that can justify it (Engineers and Geoscientists BC 2018; 2020)

3. **Use no climate tools**
   - When a small watershed has little or no local historic data, a designer can account for climate change by increasing flow by an additional 20% (Engineers and Geoscientists BC, 2018)
• Poll 1 – let's look at results
• and then start Poll 2
Steps to using a climate tool

1. Define the required input parameters, or be aware of assumptions
   - GCMs related to downscaled models
   - RCPs baked-in to GCMs
   - Baseline and future periods that define measure of change

2. Define the location of interest

3. For IDF_CC:
   - Select duration/frequency/return period to define intensity. Interpret.

For climate index climate tool:
   - Select relevant climate index that impacts design flood and assume how its temporal resolution (daily+) relates to local scale (minutes to hours). Interpret.

4. Calculate the change in flow, compare results between climate tool outputs
Applying climate tools adds uncertainties

• Choices in:
  – Global climate models (GCM) ensembles
    • Use average, or upper percentiles of distribution?
  – Representative concentration pathway (RCP) scenarios
    • Assume that climate treaties can be effective?
  – Historic baseline reference period
  – “Proxy” climate index
    • Assume known metric that relates to local scale flooding (if not using IDF_CC)
  – Assumptions that extrapolate from available data
    • changes to climate indices at a daily (or greater) resolution relate to sub-daily resolution (downscaling using professional judgement) – when using climate index tools
    • stationarity of relationships between daily (or greater) and sub-daily events – when using any climate tool

• **Review of the design flood hydrology at a site gives context**
  – What are the other uncertainties aside from climate tool inputs?
• Poll 2 results
Getting a percent change for design flood
Climate tools: case study 1

Proxy: total precipitation (winter)

<table>
<thead>
<tr>
<th>RCP</th>
<th>10th percentile</th>
<th>Average</th>
<th>90th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 8.5</td>
<td>-5%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>-5%</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>-0%</td>
<td>7%</td>
<td>16%</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

(ensemble: 12 GCMs)
Climate tools: case study 1

Unique benefit of this climate tool: desktop version can output entire maps

Many climate indices, max temporal resolution = monthly

Climate index: total precipitation in November
% change: 2070-2099 period (15 GCMs)

Producing this type of % change map requires GIS post-processing
Applying climate tools: case study 1

Proxy climate index: many to choose from...

<table>
<thead>
<tr>
<th>Climate index</th>
<th>2040-2069</th>
<th>RCP 8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total precipitation (winter)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Total precipitation (January)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (yearly storm)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (20-year storm)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (50-year storm)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Applying climate tools: case study 1

#### 2040-2069

<table>
<thead>
<tr>
<th>Climate index</th>
<th>Low perc.</th>
<th>Average</th>
<th>High perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total precipitation (winter)</td>
<td>N/A</td>
<td>5 to 7%</td>
<td>N/A</td>
</tr>
<tr>
<td>Total precipitation (January)</td>
<td>N/A</td>
<td>3 to 7%</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (yearly storm)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (20-year storm)</td>
<td>N/A</td>
<td>13 to 19%</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (50-year storm)</td>
<td>N/A</td>
<td>17 to 25%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**RCP 8.5**

**Ensemble option:**

12 GCMs

**Variance shown:** 3 different historic baselines (of 30 years)
### Applying climate tools: case study 1

#### 2040-2069

**RCP 8.5**

Manually averaging global climate models (GCMs)

Which GCMs to pick if not all 12 for BC?

https://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios

<table>
<thead>
<tr>
<th>Climate index</th>
<th>Low perc.</th>
<th>Average</th>
<th>High perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total precipitation (winter)</td>
<td>N/A</td>
<td>5 to 7%</td>
<td>N/A</td>
</tr>
<tr>
<td>Total precipitation (January)</td>
<td>N/A</td>
<td>3 to 7%</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (yearly storm)</td>
<td>16 to 19% (min of 4)</td>
<td>21 to 31%</td>
<td>40 to 54% (max of 4)</td>
</tr>
<tr>
<td>Daily precipitation (20-year storm)</td>
<td>N/A</td>
<td>13 to 19%</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (50-year storm)</td>
<td>N/A</td>
<td>17 to 25%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Variance shown: 3 different historic baselines (of 30 years)
## Applying climate tools: case study 1

### 2040-2069

#### RCP 8.5

Available (23 GCMs)

### Daily precipitation (yearly storm) – another source

<table>
<thead>
<tr>
<th>Climate index</th>
<th>10th perc.</th>
<th>Average</th>
<th>90th perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total precipitation (winter)</td>
<td>N/A</td>
<td>5 to 7%</td>
<td>N/A</td>
</tr>
<tr>
<td>Total precipitation (January)</td>
<td>N/A</td>
<td>3 to 7%</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (yearly storm)</td>
<td>-12%</td>
<td>14%</td>
<td>72%</td>
</tr>
<tr>
<td>Daily precipitation (20-year storm)</td>
<td>N/A</td>
<td>13 to 19%</td>
<td>N/A</td>
</tr>
<tr>
<td>Daily precipitation (50-year storm)</td>
<td>N/A</td>
<td>17 to 25%</td>
<td>N/A</td>
</tr>
</tbody>
</table>
**Applying climate tools: case study 1**

### IDF_CC Tool 4.0

<table>
<thead>
<tr>
<th>Duration</th>
<th>25&lt;sup&gt;th&lt;/sup&gt; perc.</th>
<th>Average</th>
<th>75&lt;sup&gt;th&lt;/sup&gt; perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 mins</td>
<td>9%</td>
<td>13%</td>
<td>30%</td>
</tr>
<tr>
<td>720 mins</td>
<td>12%</td>
<td>18%</td>
<td>33%</td>
</tr>
<tr>
<td>60 mins</td>
<td>-4%</td>
<td>9%</td>
<td>14%</td>
</tr>
<tr>
<td>720 mins</td>
<td>-2%</td>
<td>12%</td>
<td>19%</td>
</tr>
</tbody>
</table>

2040-2069

RCP 8.5

2040-2069

RCP 4.5

IDF point as baseline
## Applying climate tools: case study 2

### IDF_CC Tool 4.0

#### Climate Index

<table>
<thead>
<tr>
<th>Climate index</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily precipitation (50-year storm)</td>
<td>4 to 8%</td>
</tr>
<tr>
<td>Daily precipitation (50-year storm)</td>
<td>19 to 22%</td>
</tr>
</tbody>
</table>

### Duration

<table>
<thead>
<tr>
<th>Duration</th>
<th>25&lt;sup&gt;th&lt;/sup&gt; perc.</th>
<th>Average</th>
<th>75&lt;sup&gt;th&lt;/sup&gt; perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 mins</td>
<td>0%</td>
<td>5%</td>
<td>25%</td>
</tr>
<tr>
<td>60 mins</td>
<td>-2%</td>
<td>6%</td>
<td>25%</td>
</tr>
<tr>
<td>30 mins</td>
<td>0%</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td>60 mins</td>
<td>4%</td>
<td>13%</td>
<td>25%</td>
</tr>
</tbody>
</table>

#### 2010-2039

- **RCP 8.5**

#### 2040-2069

- **RCP 8.5**
Thank you

Matt Kurowski
Researcher
FPInnovations

matt.kurowski@fpinnovations.ca