Quantification of uncertainty in high resolution temperature scenarios for North America

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Outline

• Introduction
• Methodology
• Results
• Conclusions
Introduction – Objective

• Construct high resolution monthly temperature over North America

• Estimate high resolution scenario uncertainty in the projected temperature

• Partition uncertainty into different sources
Introduction – Data

• GCM data – PCMDI
  – 23 GCMs, resolution 100 – 400km, 1961-2099
  – 2 emission scenarios – A2 and B1
  – 38 runs from SRES-A2 and 44 runs from SRES-B1

• RCM data – NARCCAP

<table>
<thead>
<tr>
<th>GCM/RCM</th>
<th>GFDL</th>
<th>CGCM3</th>
<th>HADCM3</th>
<th>CCSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRCM</td>
<td>--</td>
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<td>--</td>
<td>finished</td>
</tr>
<tr>
<td>ECPC</td>
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<td>--</td>
<td>planned</td>
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<td>--</td>
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<tr>
<td>MM5I</td>
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<td>--</td>
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<td>finished</td>
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<tr>
<td>RCM3</td>
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<td>finished</td>
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<td>--</td>
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<tr>
<td>WRFP</td>
<td>--</td>
<td>planned</td>
<td>--</td>
<td>finished</td>
</tr>
</tbody>
</table>
Introduction – Data treatment

- All GCMs and RCMs are interpolated to CRCM grid points
- Inverse distance for GCMs
  - Four surrounding points
- Nearest assignment for RCMs
  - RCM3 and WRFP to CRCM
  - Over 90% of the grid points are within 45km
- Remove 1971-2000 climatology
  - CRCM, RCM3, WRFP and corresponding driven GCM
  - All GCMs from PCMDI
Methodology

Five RCM Outputs
Anomaly Temperature

Linear regression

Three driven GCMs
Anomaly Temperature

\[ y_t = \beta_0 + \beta_1 t + \beta_2 x_t + \varepsilon_t \]

23 GCM Models
(38 runs from SRES-A2 and 44 runs from SRES-B1)
Monthly or seasonal temperature change in CMIP3
Randomly sample 100 values from each run

\[ \hat{\beta}_0 + \hat{\beta}_1 t' + \hat{\beta}_2 x_{t,j} \]

Probabilistic Prediction on High Resolution
Temperature Changes and Uncertainties

Source of Uncertainties
Analysis of Variance

\[ Y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_l + \rho_{m(j)} + (\alpha\beta)_{ij} + (\alpha\gamma)_{il} + (\beta\gamma)_{jl} \]
\[ + (\alpha\beta\gamma)_{ijl} + (\alpha\rho)_{im(j)} + (\gamma\rho)_{lm(j)} + (\alpha\gamma\rho)_{ilm(j)} + \varepsilon_{ijklm} \]
Result – Model Validation
Statistically and dynamically downscaled temperatures

RMSE:

Regression residual

CRCM/CGCM3

Statistical downscaling
CRCM/CGCM3 to GFDL

Dynamical downscaling
RCM3/GFDL
## Results – Winter temperature change

<table>
<thead>
<tr>
<th>Year Range</th>
<th>10th percentile</th>
<th>Median</th>
<th>90th percentile</th>
</tr>
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<tbody>
<tr>
<td>2011-2040</td>
<td><img src="image1" alt="Map" /></td>
<td><img src="image2" alt="Map" /></td>
<td><img src="image3" alt="Map" /></td>
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<tr>
<td>2041-2070</td>
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<td>2071-2099</td>
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<td><img src="image8" alt="Map" /></td>
<td><img src="image9" alt="Map" /></td>
</tr>
</tbody>
</table>

- **10th percentile**
- **Median**
- **90th percentile**
Results – Summer temperature change

10th percentile | Median | 90th percentile

2011-2040

2041-2070

2071-2099
Results – Source of Uncertainty

\[ Y_{ijlmk} = \mu + \alpha_i + \beta_j + \gamma_l + \rho_{m(j)} + (\alpha\beta)_{ij} + (\alpha\gamma)_{il} + (\beta\gamma)_{jl} + (\alpha\beta\gamma)_{ijkl} + (\alpha\rho)_{im(j)} + (\gamma\rho)_{ilm(j)} + (\alpha\gamma\rho)_{ilm(j)} + \varepsilon_{ijlmk} \]
Conclusions

• A framework was constructed by using combined dynamical and statistical downscaling methods to produce high resolution temperature scenarios over North America

• Multiple GCMs and RCMs relationships were applied to CMIP3 GCM simulations for emulating RCM simulations

• Uncertainty from GCM, regression model, internal variability, and downscaling from low resolution to high resolution were estimated

• Provide a product with high resolution monthly and seasonal temperature change and uncertainty
Thank you!