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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

GCM / RCM	GFDL	CGCM3	HADCM3	CCSM
CRCM	--	finished	--	finished
ECPC	running	--	planned	--
HRM3	planned	--	finished	--
MM5I	--	--	planned	finished
RCM3	finished	finished	--	--
WRFP	--	planned	--	finished

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

$$y_t = \beta_0 + \beta_1 t + \beta_2 x_t + \varepsilon_t$$

$$\hat{\beta}_0 + \hat{\beta}_1 t' + \hat{\beta}_2 x_{t'j}$$

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

$$\hat{\sigma}^2(1 + X_h^{'}(X'X)^{-1}X_h)$$

Probabilistic Prediction on High Resolution
Temperature Changes and Uncertainties

Source of Uncertainties
Analysis of Variance

$$Y_{ijlmk} = \mu + \alpha_i + \beta_j + \gamma_l + \rho_{m(j)} + (\alpha\beta)_{ij} + (\alpha\gamma)_{il} + (\beta\gamma)_{jl} + (\alpha\beta\gamma)_{ijl} + (\alpha\rho)_{im(j)} + (\gamma\rho)_{lm(j)} + (\alpha\gamma\rho)_{ilm(j)} + \varepsilon_{ijlmk}$$

Result – Model Validation

Statistically and dynamically downscaled temperatures

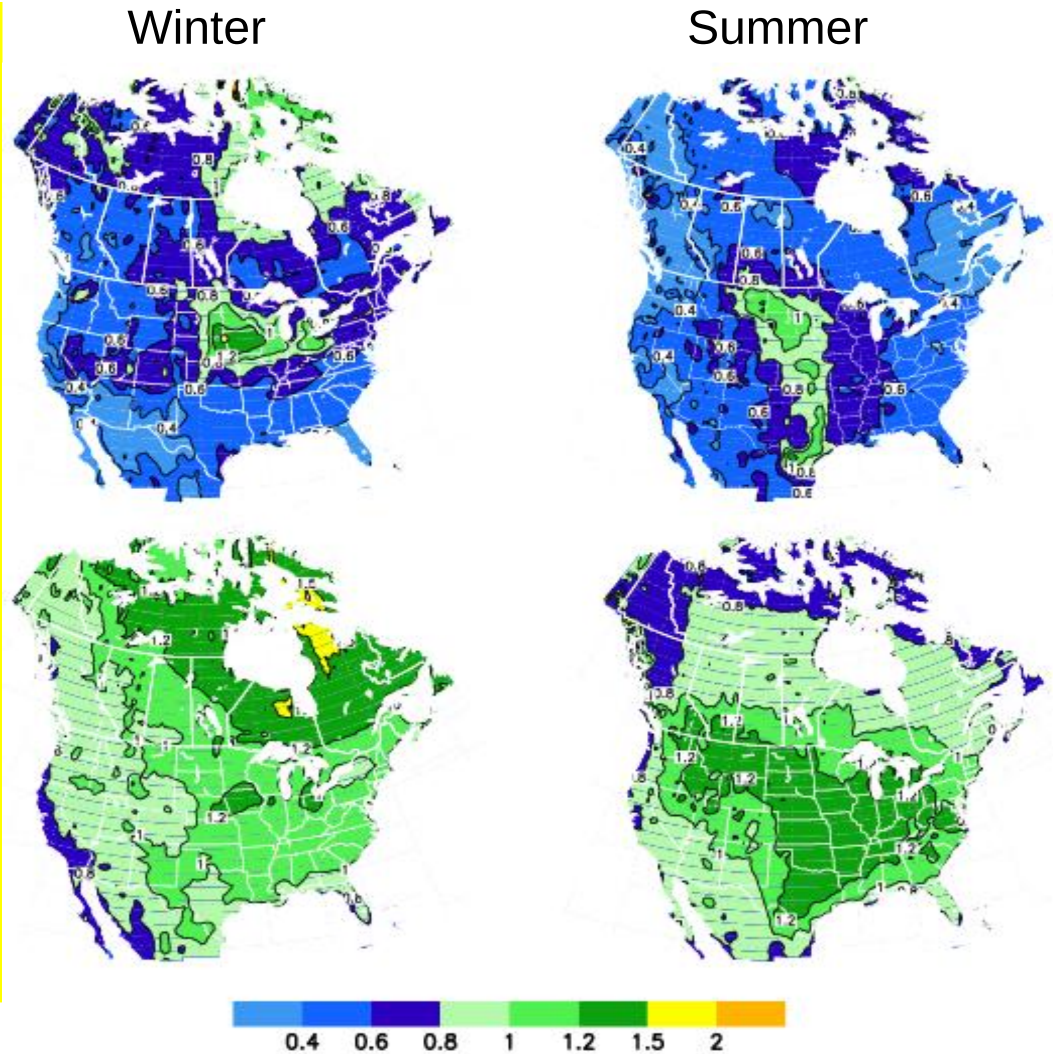
RMSE:

Regression residual

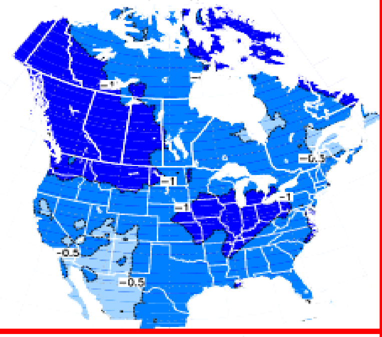
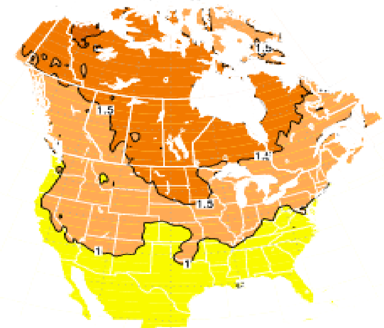
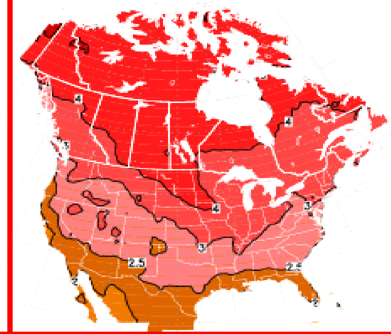
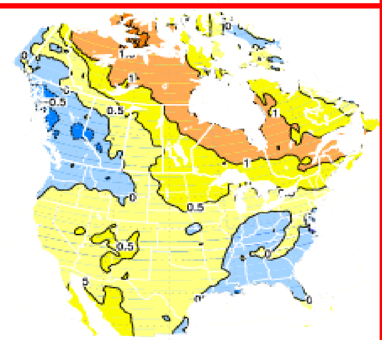
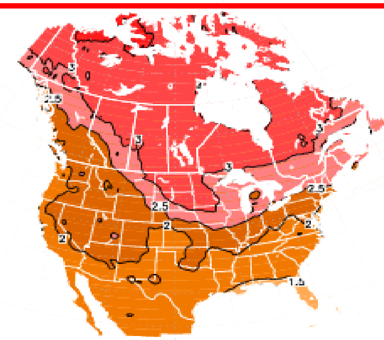
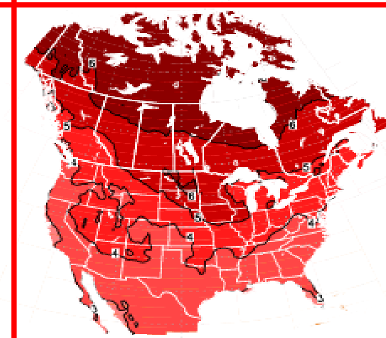
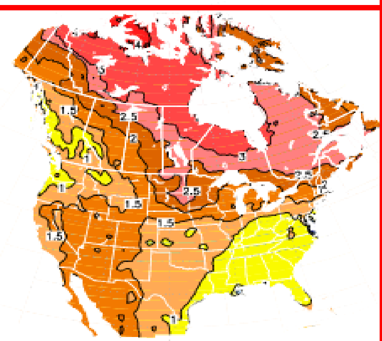
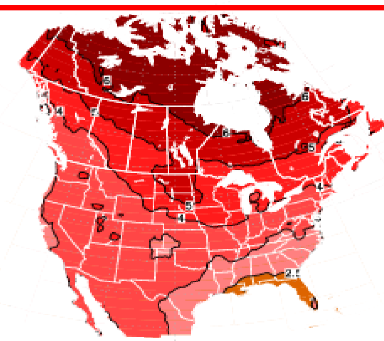
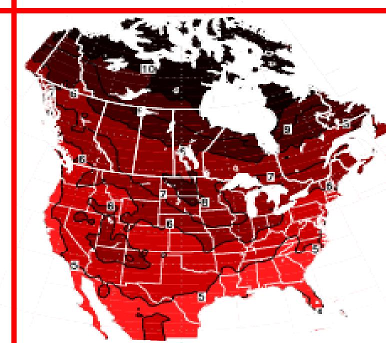
CRCM/CGCM3

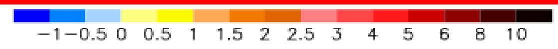
Statistical downscaling CRCM/CGCM3 to GFDL

Dynamical downscaling RCM3/GFDL



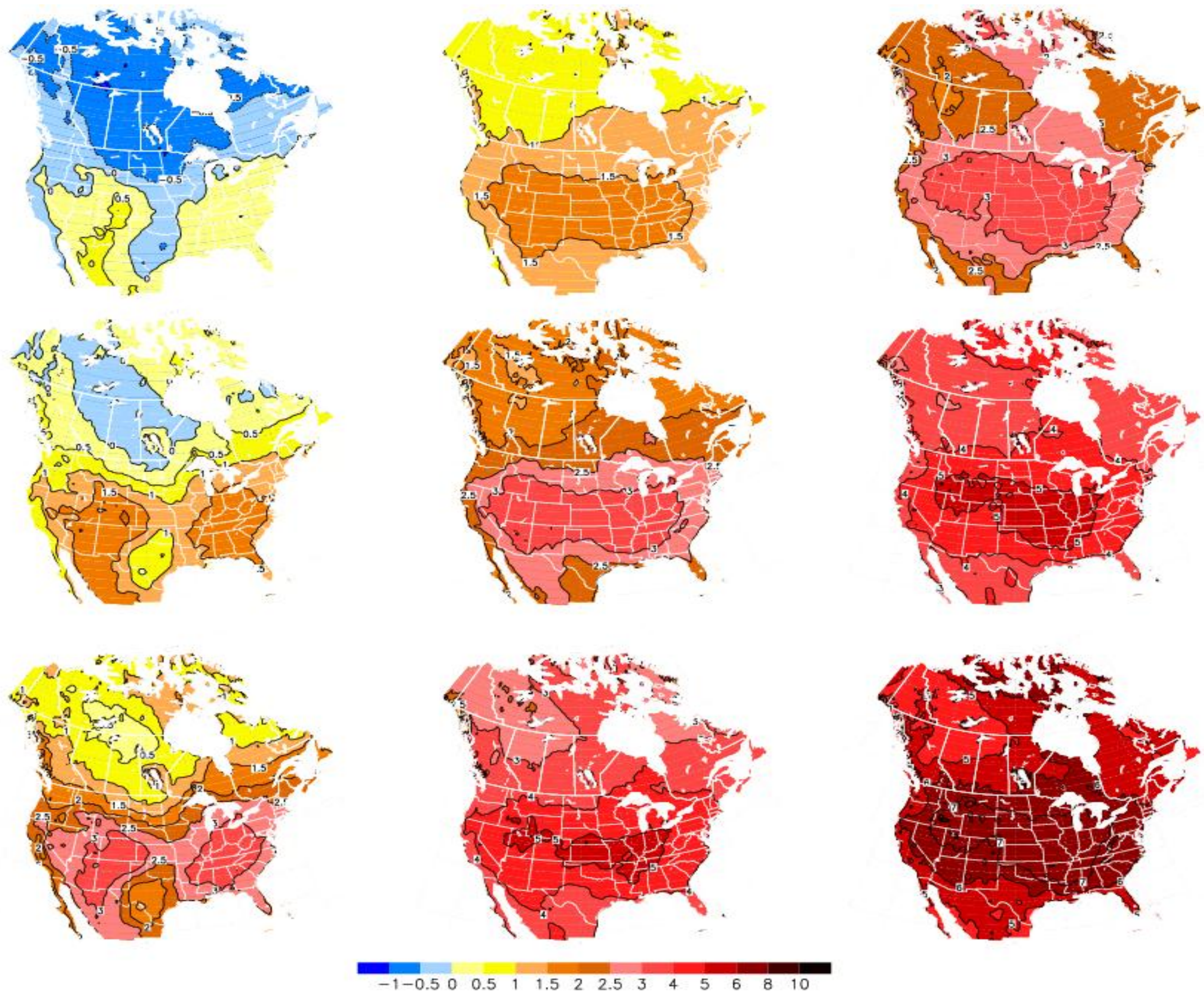
Results – Winter temperature change

	10th percentile	Median	90th percentile
2011-2040			
2041-2070			
2071-2099			



Results – Summer temperature change

	10th percentile	Median	90th percentile
2011-2040			
2041-2070			
2071-2099			



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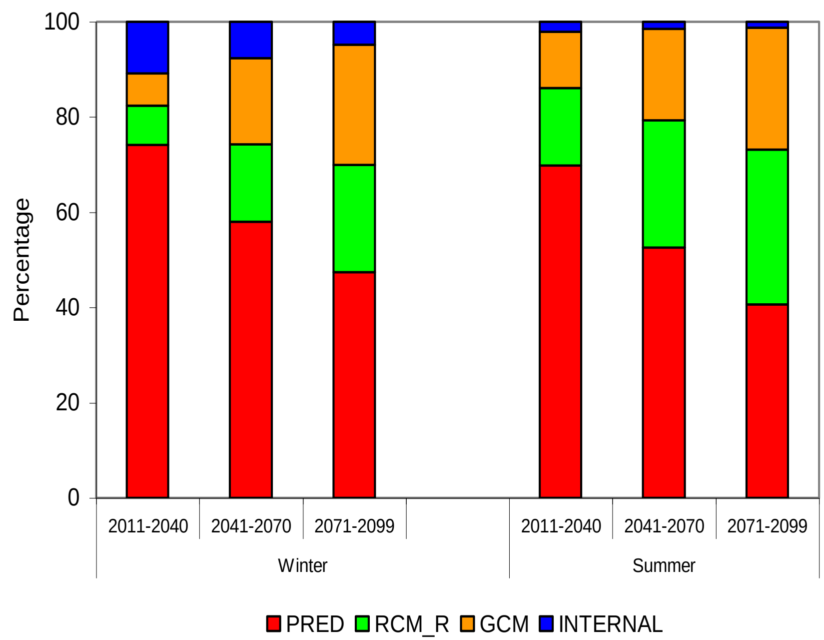
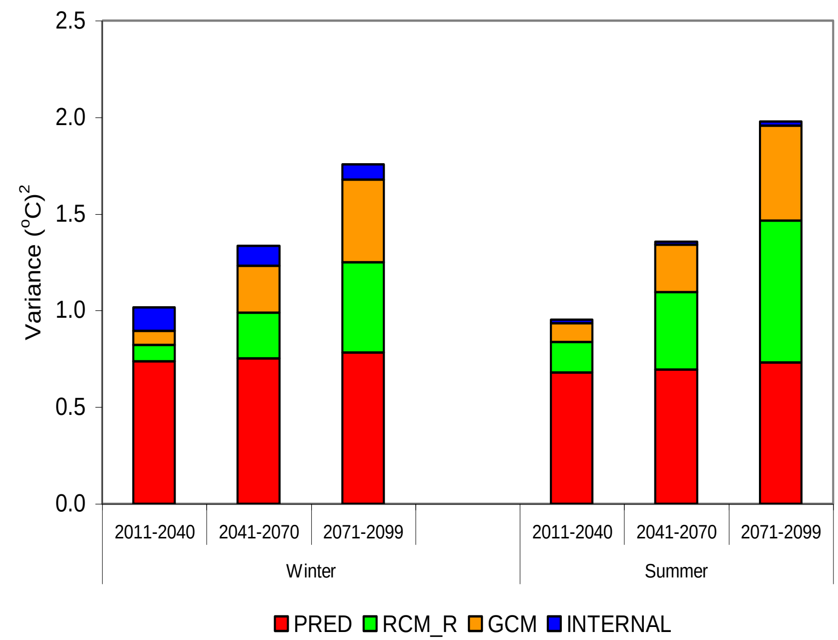
Results – Source of Uncertainty





$$Y_{ijlmk} = \mu + \alpha_i + \boxed{\beta_j} + \boxed{\gamma_l} + \boxed{\rho_{m(j)}} + (\alpha\beta)_{ij} + (\alpha\gamma)_{il} + (\beta\gamma)_{jl} + (\alpha\beta\gamma)_{ijl} + (\alpha\rho)_{im(j)} + (\gamma\rho)_{lm(j)} + (\alpha\gamma\rho)_{ilm(j)} + \boxed{\varepsilon_{ijlmk}}$$

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!