Estimating uncertainties in global and North American regional climate change projections using a multi-thousand member climate model ensemble: Evaluation of the control simulations

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1. Introduction

A multi-thousand member perturbed-physics ensemble of climate model simulations is used to better estimate model uncertainties in climate change projections for the globe, North American regions and sub-regions within the United States. Ensemble members have been generated by the distributed computing project climate*prediction*.net at the University of Oxford, where thousands of simulations have been run on individual computers across the globe, each running a different coupled atmosphere-ocean general circulation model with perturbed physics parameters. The following provides an overview of the research method and objectives and an evaluation of the model control simulations.

2. Climate Model Simulations

Climate*prediction*.net

- Distributed computing project (Over 50,000 active hosts worldwide)
- Each computer running a slightly different climate model simulation
- Physics and forcing parameters varied across current range of uncertainty

Climate Model HadCM3L – version of UK Met Office Hadley Centre Model

- Coupled atmosphere-ocean general circulation model
- Atmosphere (19 vertical levels; 2.5° lat by 3.75° long horizontal resolution)
- Ocean (20 vertical levels; 2.5° lat by 3.75° long horizontal resolution)

Simulation Experiments

- Generate 1921-2080 control simulation ensemble (constant forcing)
- Generate 1921-2080 transient simulation ensemble (forcing varies)
  - 1921-2000: Apply historical forcings based on observations
  - 2001-2080: Apply possible future forcings (using SRES A1B)
- Vary model parameters within current range of uncertainty across ensembles
- Result in more than 3500 control simulations and 6800 transient simulations

Simulation Output

- Globally gridded 10-year means (2.5° latitude by 3.75° longitude)
- Global and regional time series monthly means (1921-2080)

3. Research Objectives

Initial Goals

- Extract climate model output for globe, North American regions and gridded sub-regions (regions follow Giorgi and Francisco (2000)
- Evaluate performance of control simulation mean climate and variability compared to detrended observational data
- Compare "transient – control" 20th century climate variations to observational data
- Generate 21st century climate change projections by weighting ensemble members according to their goodness-of-fit to historical observations
- Produce probability distributions of future climate condition

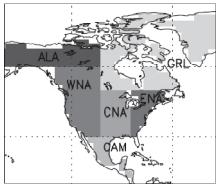


Figure 2: Regions used for North America analysis. From Giorgi and Francisco (2000).

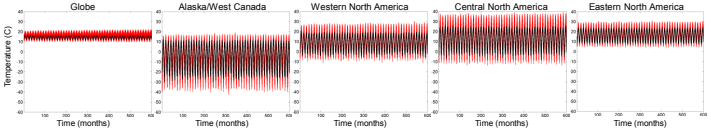
Long-term Goals

- Evaluate relationships between global and regional climate changes
- Investigate correlations between output quantities within and across regions
- Evaluate uncertainties in global and regional climate change projections for variations in model physics parameters

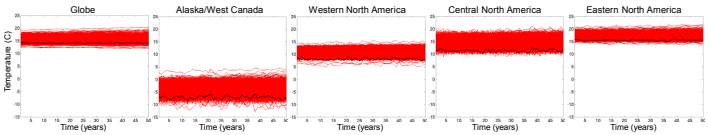
4. Control Simulation Surface Air Temperature

Red Lines – Control Simulation Ensemble **Black Line** – Detrended HadCRUT3 data, 1961-2009 (Brohan et al., 2006)

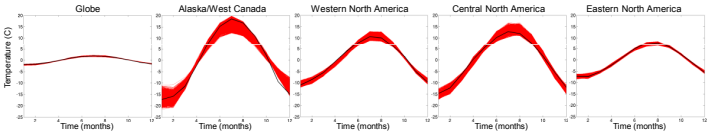
Monthly Mean Surface Air Temperature



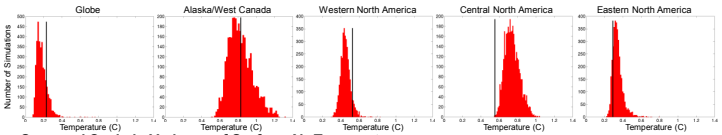
Annual Mean Surface Air Temperature



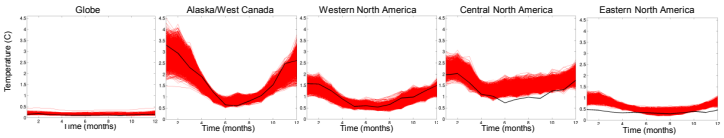
Mean Seasonal Cycle in Surface Air Temperature



Interannual Variability in Surface Air Temperature



Seasonal Cycle in Variance of Surface Air Temperature



5. Surface Air Temperature Summary

- Generally good agreement between control simulations and detrended observational data
- Simulations contain slight warm bias compared to observations in all regions
- Simulated mean seasonal cycle is consistent with observations across all regions
- Simulated interannual variability is consistent with observations over Western Canada but simulations contain slightly larger (smaller) variability in Central and Eastern NA (Global and Western NA) regions
- Greater variance in winter occurs in all NA regions for both simulations and observations

References

Adler, R.F., G.J. Huffman, A. Chang, R. Ferraro, P. Xie, J. Janowiak, B. Rudolf, U. Schneider, S. Curtis, D. Bolvin, A. Gruber, J. Susskind, P. Arkin, and E. Nelkin 2003: The Version 2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979-Present). *J. Hydrometeor.*, **4**,1147-1167.

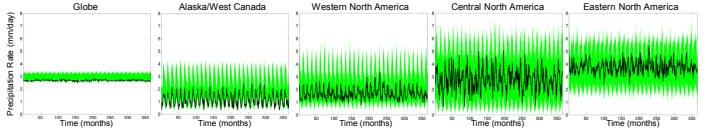
Brohan, P., J.J. Kennedy, I. Harris, S.F.B. Tett and P.D. Jones. 2006: Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. *J. Geophysical Research* **111**, D12106, doi:10.1029/2005JD006548

Giorgi, F., and R. Francisco, 2000: Uncertainties in regional climate change predictions. A regional analysis of ensemble simulations with the HadCM2 coupled AOGCM. *Climate Dyn.*, **16**, 169-182.

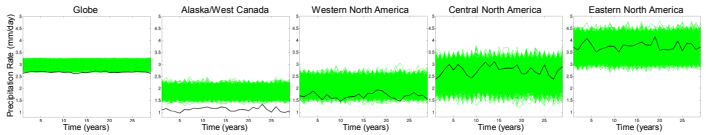
6. Control Simulation Precipitation Rate

Green Lines – Control Simulation Ensemble **Black Line** – Detrended GPCP data, 1979-2009 (Adler et al., 2003)

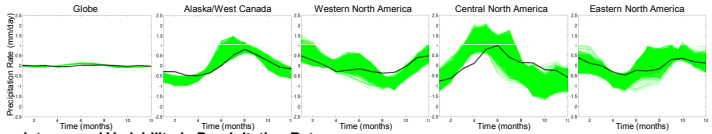
Monthly Mean Precipitation Rate



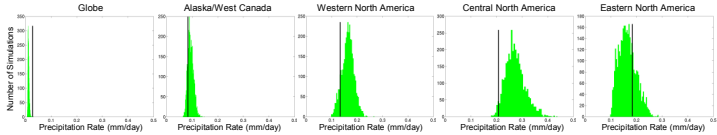
Annual Mean Precipitation Rate



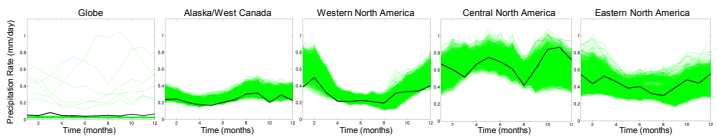
Mean Seasonal Cycle in Precipitation Rate



Interannual Variability in Precipitation Rate



Seasonal Cycle of Variance in Precipitation Rate



7. Precipitation Rate Summary

- Generally good agreement found between control simulations and detrended observational data
- Larger precipitation rates found in simulated monthly and annual means for the globe, Western Canada and Western NA than found in observations
- Simulated mean seasonal cycle is similar to observed cycle but exact timing of maximum and minimum precipitation rate can be slightly shifted
- Simulated interannual variability is fairly consistent with observations in Western Canada and Eastern NA but is slightly larger (smaller) in Western NA and Central NA (Globe)

Acknowledgements

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