2020/06/07

Statistical downscaling and bias correction of climate model outputs for climate change impact assessment in the U.S. northeast

Kazi Farzan Ahmed · Guiling Wang · John Silander · Adam M. Wilson · Jenica M. Allen · Radley Horton · Richard Anyah

Global and Planetary Change 100 (2013) 320–332
DOI: 10.1016/j.gloplacha.2012.11.003
Accepted: 11 November 2012

Introduction:

· Dynamic Downscaling,

· Bias Correction and Spatial Disaggregation (BCSD),

· Bias Correction and Constructed Analogs (BCCA),

· Abatzoglou and Brown using BCCA method successfully reproduced daily stream flow observed at 11 stations in California (AB11),

· Statistical Downscaling and Bias Correction (SDBC).

Data and study site:

研究地区：the New England region (ranges from 67.0625 W to 75.0625 W in longitudes and from 38.8125 N to 48.8125 N in latitudes).

研究变量：

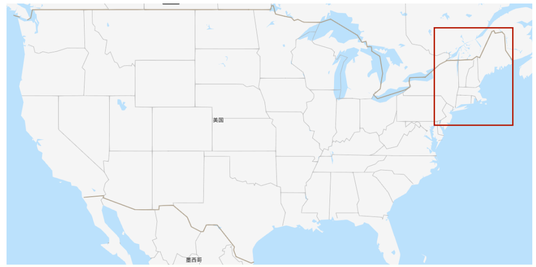


Table 1
Extreme climate indicators which were selected and analyzed in this study.

Extreme Indicators	Definitions	Unit
Fd	Total number of frost days, defined as the number of days per year with minimum temperature below 0 °C	Days
GSL	Growing season length, defined as the period between the first spell of five consecutive days with mean temperature above 5 °C and the first spell of five consecutive days with mean temperature below 5 °C	Days
TGO	Time when the greenup onset occurs in the spring	Julian day
R5d	Maximum 5-day total precipitation	mm
R10	Total number of days with precipitation greater than 10 mm	Days

研究时间：1961 - 1999, 2046-2065;

数据：

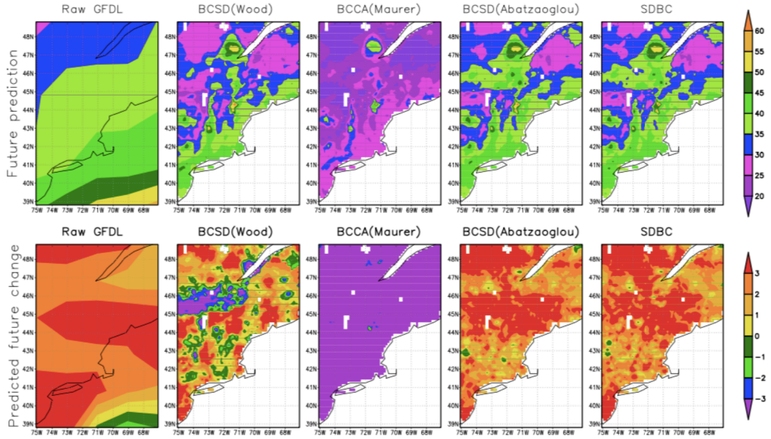
·*Observed data:* developed by Maurer et al. (2002).

·*Models:* CCSM, GFDL, PCM, CGCM, MPI, MIROC.

Methods:

The downscaling is applied to a 'factor value'. The 'factor' for precipitation is the ratio of model precipitation to observed precipitation aggregated to the model resolution, and for temperature is the difference between model temperature and observed temperature aggregated to the model resolution.

Results:



Future mean (2046–2065) of total number of days with precipitation greater than 10 mm from raw GFDL and spatially downscaled and bias corrected GFDL data using the BCSD, the BCCA, the Abatzoglou and Brown, and the SDBC ds (top row), and respective predicted changes from present-day mean (1961–1999) (bottom row).

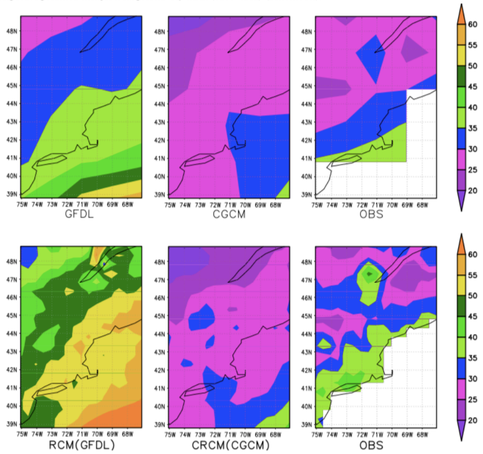


Table 2
Root-mean-square error (RMSE) and coefficient of determination (R^2) for present-day (1971–1995) mean of R10, based on comparison of model present-day climate against observation.

Model	GFDL	CGCM	RCM_GFDL	CRCM_CGCM
RMSE	4.94	5.14	13.13	26.22
R^2	0.51	0.32	0.27	0.15

Fig. 2. Mean values of total number of days with precipitation greater than 10 mm in present climate which were calculated using raw GCM simulations (1961–1999) at 2° and dynamically downscaled RCM simulations (1971–1995) at 0.5° and their comparisons with observation at their corresponding resolutions.

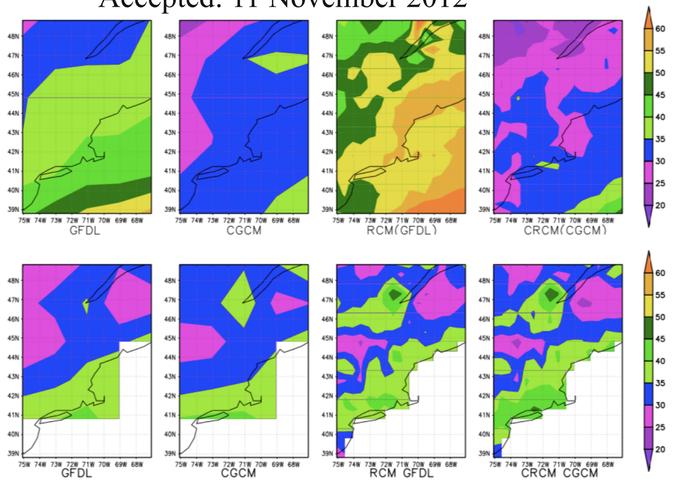


Fig. 3. Future mean (2046–2065) of total number of days with precipitation greater than 10 mm for GCMs (2°) and RCMs (0.5°), based on raw (top row) and bias corrected (bottom row) outputs.

Table 3
Root-mean-square deviation (RMSD) and coefficient of determination (R^2) between two models for future (2046–2065) mean of R10, based on raw model output and bias corrected model outputs.

Models	GFDL and CGCM (Raw/bias corrected)	RCM_GFDL and CRCM_CGCM (Raw/bias corrected)
RMSD	8.81/2.58	22.35/2.09
R^2	0.44/0.80	0.52/0.86

Conclusions:

1. 进行了偏差校正的统计降尺度方法可以有效的从GCMs输出的粗糙分辨率中得到高精度的被预报量；然而统计降尺度的这一优势会针对研究的范围而改变
2. 通过6个GCM和4个RCM无法充分得到未来气候变化的信息；
3. 本文发现，由于未来气候增暖导致，霜冻天数减少，且减少的幅度在整个US的东北地区表现均一；由于未来春天提前到来且秋天的到来延迟，导致农作物生长季节增加；降水超过10mm的天数在东北地区增加，但是在局部地区却又减少；
4. SDBC方法，和其他统计降尺度方法一样，具有保留大尺度天气变化信号的能力。

Report

2020.06.09

張慕琪

- **Outline** (Develop high-resolution statistical downscaling dataset for China's climate change using artificial neural network method)
  - Introduction
  - Method and Data
  - ~~Results~~
    - ~~Historical~~
    - ~~Future~~
  - ~~Discussions and Conclusions~~

Introduction

- 全球变暖是当今世界最重要的科学问题之一。许多研究指出，日最高温和日最低温受气候变化的影响不同。中国受气候变化有……影响（引用前人文章，主要围绕tmax & tmin & pr）。因此，越来越多的决策者和研究学者开始重视对气候变化影响的评估。***[Global climate change is one of the most important scienticif issues in the world.]***
- 尽管GCMs是如今用于未来气候预测的常用工具，但是其空间分辨率太过粗糙，无法满足更精确的研究需求。同时，所有模式的输出都有一定的偏差，如果不做订正，会导致评估产生较大的误差。所有的气候影响评估都需要观测数据的支持，但是观测数据并没有未来的气候信息。因此，对GCMs进行空间降尺度和偏差校正是十分必要的。***[Global climate models are powerful tool for assessing how the global cliamte may change in the future.]***
- 通常有两种降尺度方式：统计降尺度和动力降尺度。什么是统计降尺度，什么是动力降尺度。因为统计降尺度具有灵活、计算代价小等优势，因此我们使用该方法。前人使用Bias Correction and Constructed Analogs (BCCA)的统计降尺度方法进行统计降尺度+该方法弊端 (Maurer and Hidalgo (2008), Maurer et al. (2010)); 同时，NEX-GDDP使用BCSD方法对21个GCMs做了统计降尺度；基于AI的一系列方法也被应用于研究降尺度问题。但是现如今，缺少专门针对中国地区的高时间、高空间分辨率气候变化数据。我们希望能够发展一套具有实用价值的数据集。***[Downscaling techniques are typically classified into statistical and dynamical.]***
- 如今，人工神经网络方法兴起。人工神经网络被认为具有解决预报因子和被预报量之间拥有十分复杂联系的问题的能力。因此，我们尝试发掘人工神经网络的潜在价值，用于生成一套针对中国地区的高分辨率数据。***[Artificial neural network (ANN) is a black box, with the ability to extract complicated relations between predictor and predicated variables.]***
- 本文结构组成。*[Section 2 describes the data, methodology…. Section 3 presents results…. Section 4 summarizes the results and presents the conclusions.]*

- # Method and Data
  - **Data and Study area**
    - 本文关注日降水、日最高温和日最低温三个研究变量。研究地区为中国（图）。选用的GCM一共六个：2个来自北美，2个来自欧洲，2个来自亚洲（表格）；观测数据选用GMFD。时间段分为历史阶段和未来两个；未来阶段的排放情景选取RCP2.6和RCP8.5两个。train & validation & future projection period的划分以及这样做的目的（train和validation这样的安排利于让ANN获得更多气候变暖的趋势信息）。***[Daily precipitation, maximum temperature and minimum temperature data during historical period and future period are taken from 6 GMCs.]***
  - **Methodology:**
    - 简单介绍什么是人工神经网络。关于本文使用的MLPRegressor网络的具体架构描写（图），使用RMSE作为模型的损失函数（公式），关于出现过拟合问题的解决方案（设置判断条件）。***[The brain is a remarkable computer, ANNs are disigned as biological models of simulating human brains.]***
    - 对于温度变量，格点选取为 (9GCM—>1Obs)以使ANN可以得到更多大尺度信息；用线性回归模型和ANN进行比较；对于ANN方法，future projection上需要做有偏的标准化，因为无偏的标准化方法抹去了未来气候变暖这一重要信息。***[In this study, artificial neural networks are used to downscale daily maximum (Tmax) and daily minimum (Tmin) temperature.]***
    - 由于统计降尺度自身的缺陷导致ANN的方差小于obs，引出BC的必要性。关于Bias Correction方法的描述（提供公式），谈该公式的意义：既可保证降尺度后温度的平均值可以和obs保持一致，又可以将方差放大到obs的尺度。***[In general, statistical downscaling often underestimate the variance.]***
    - 对于降水变量，格点选取为 (1—>1)，用柏松回归模型和仅做了Bias Correction（公式）做比较，提及不对降水使用ANN方法的原因（ANN输出每天下小雨的现象）。***[As for daily precipitaion, we only use bias correction method.]***
    - 对historical阶段和future projection阶段结果分析。*[……]*

谢谢