Comparing Joint Variable Spatial Downscaling Results with NARCCAP Datasets

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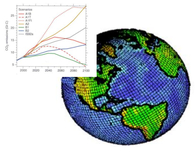
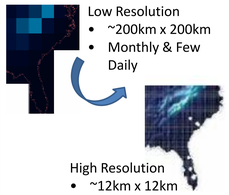
Introduction



General Circulation Models (GCMs) are broadly used as an important tool for qualitative impact assessment. The GCMs represent (through a large system of partial differential equations) the coupled atmospheric and oceanic processes currently understood to govern the Earth's climate.



At present, GCMs run on global scales at relatively low spatial resolutions (~100x100 km2 to ~250x250 km2). Because of their coarse spatial resolution, GCM outputs are usually inadequate to capture the spatial variability at regional or local scales with higher resolution (~4x4 km2 to ~12x12 km2) necessary for hydrological applications.

Figure 1 Low & High Resolution Grids

Joint Variable Spatial Downscaling (JVSD), a new statistical technique for downscaling gridded climatic variables, is developed to generate high resolution gridded datasets for regional watershed modeling and assessments.

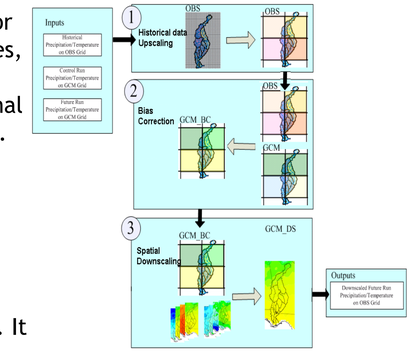


Figure 2 Joint Variable Spatial Downscaling Flowchart

The proposed approach differs from previous statistical downscaling methods in that multiple climatic variables are downscaled simultaneously and consistently to produce realistic climate projections. It has two major steps: bias correction and spatial downscaling.

Upscaling and Differentiation

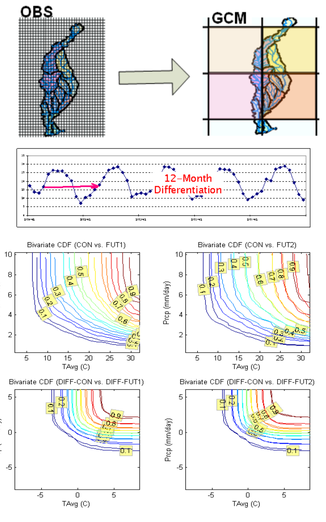


Figure 3 Bivariate Empirical Cumulative Frequency Curves for Original (Top) and Differenced (Bottom) Time Series of Temperature and Precipitation

Figure 3 shows that,

(1) The joint frequency distributions of temperature and precipitation are different in the control and future runs; and

(2) The relationship of the joint frequency distributions (of control versus future data) is appreciably different in the first versus the second 50-year period, indicating that the joint frequency distribution is non-stationary; and

(3) The differenced sequences exhibit very good correspondence between control and future runs, for both future periods. This result and conclusion has been tested and shown to hold for all 13 GCMs available through IPCC.

Bias Correction

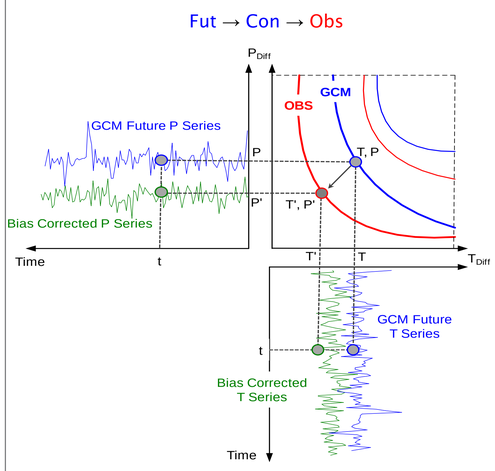


Figure 4 Joint Frequency Distribution Mapping

(1) Creating a differenced series of future temperature and precipitation;

(2) Finding the joint frequency of the contemporaneous differenced data values;

(3) Considering that this joint frequency is the same in the future differenced series as it is in the control differenced series; and

(4) Mapping each joint frequency point of the GCM control distribution to a corresponding point on the joint frequency distribution of the observed differenced series.

Spatial Downscaling

(1) Pattern matching is performed simultaneously for temperature and precipitation fields;

(2) Pattern matching is performed simultaneously for all GCM cells that cover the region of interest; and

(3) Future temperature and precipitation fields that fall outside the historical range are accommodated by expanding the range of historical analogues.

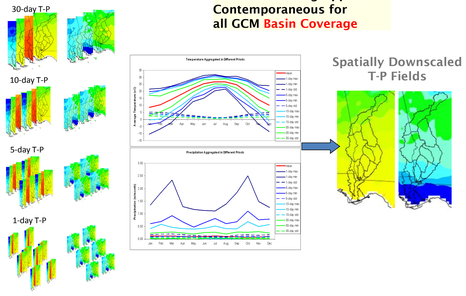


Figure 5 Spatial Downscaling using Historical Analog Approach

Downscaling Results for CGCM3.1-run1 (A1B Scenario)

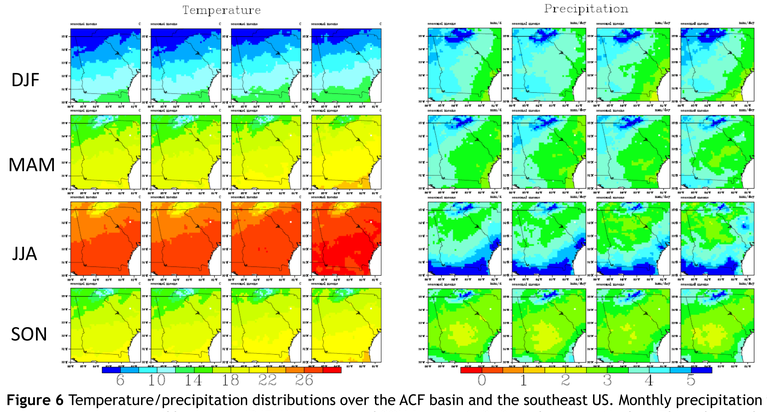


Figure 6 Temperature/precipitation distributions over the ACF basin and the southeast US. Monthly precipitation fields are aggregated by season (DJF, MAM, JJA, and SON in rows 1, 2, 3, and 4 respectively). The columns depict observations for the period 01/1950 - 12/1999 (Column 1); JVSD downscaled data using input from the 20CM3 experiment for the period 01/1950 - 12/1999 (Column 2); JVSD downscaled data using input from the CGCM3.1-run1A1B Scenario for the period 01/2000-12/2049 (Column 3); and JVSD downscaled data using input from the CGCM3.1-run1 A1B Scenario for the period 01/2050-12/2099 (Column 4).

Comparison With Dynamic Downscaling Results

	Phase I	Phase II			
	NCEP	GFDL	CGCM3	HADCM3	CCSM
CRCM	finished	--	finished	--	finished
ECP2	finished	running	--	planned	--
HRM3	finished	planned	--	finished	--
MM5I	finished	--	--	planned	finished
RCM3	finished	finished	finished	--	--
WRFG	finished	--	running	--	finished
Timeslices	finished	--	--	finished	

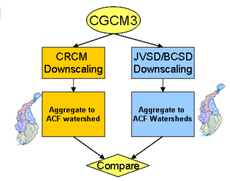


Figure 7 Comparison Process of JVSD with Dynamic Downscaling Methods from the NARCCAP Dataset (CRCM/CGCM3) for the Future Period 2041-2070) Reference: NARCCAP: http://www.narccap.ucar.edu/index.html

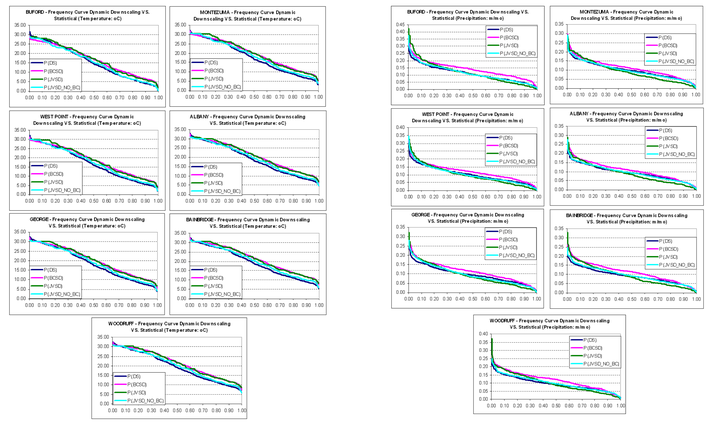


Figure 8 Comparisons of Downscaled Temperature/Precipitation Frequencies for ACF Watersheds based on NARCCAP Methods, BCSD, JVSD with no bias correction, and JVSD with bias correction
Reference: Wood, A. W., L. R. Leung, V. Sridhar and D. P. Lettenmaier, (2004). "Hydrologic Implications of Dynamical and Statistical Approaches to Downscaling Climate Model Outputs." Climatic Change 62.1-3: 189-216.

Climate Change Assessment for ACF Basins

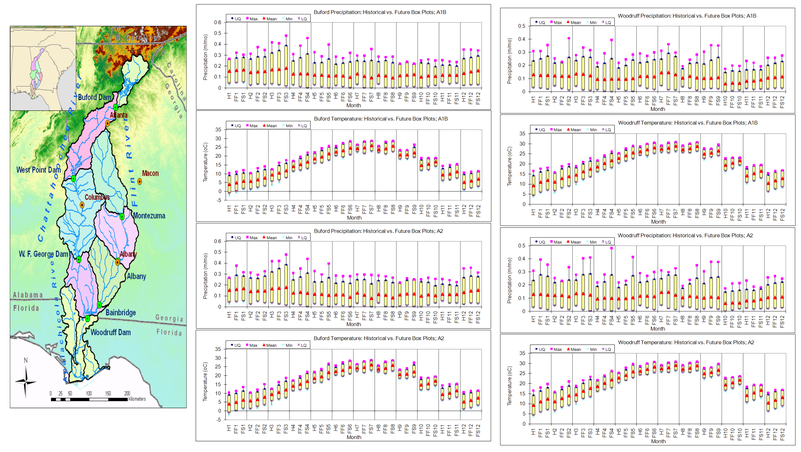


Figure 9 Box Plots of Monthly Historical vs. Future (A1B and A2) Watershed Precipitation and Temperature:
H denotes the historical period (1950-1999); FF the first future period (2000-2049); and FS the second future period (2050-2099). Left - Buford Watershed; Right - Woodruff Watershed.
Reference: F. Zhang and A. Georgakakos, (2010). "Joint Variable Spatial Downscaling",Climatic Change, submitted

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