Improving statistically downscaled daily data for hydrology: diagnosis and opportunities
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ABSTRACT
Incorporation of climate change information into long-term evaluations of water and energy resources. A primary challenge facing resource managers in accommodating climate change is determining the range and uncertainty in regional and local climate projections. Some global climate models (GCMs) produce output at a spatial scale incompatible with local impact assessment. Different techniques have evolved to downscale GCM output so locally important climate features are expressed in the projections. Recent research has compared skill using two statistical downscaling methods, the constructed analogues (CA) and the bias correction and spatial downscaling (BCSD). The CA method uses daily GCM output and the BCSD monthly. We evaluate the downscaled precipitation and temperature (from the NCEP/NCAR reanalysis and a GCM) for the late 20th century against observations, and compare projections with both methods. We include an assessment of the GCM biases, and present a new method for correcting for GCM biases in a hybrid method combining the most important characteristics of both methods.

Downscaling with BCSD

Step 1: Bias-Correction
- Use quantile mapping to ensure monthly statistics (at GCM scale) match
- Apply same quantile mapping to "projected" period

Step 2: Spatial Downscaling
- Use bias-corrected monthly GCM output
- Aggregate obs to GCM scale
- Calculate P.T. factors relative to coarse-scale climatology
- Apply to fine-scale climatology
- Daily Values from rescaled historical values

Comparing BCSD and CA

Characteristics in Common
- Both provide spatially continuous (gridded) downscaled fields
- Observed spatial and temporal climate structure maintained
- Automated and efficient: can be used for ensembles of GCMs
- Capable of downsampling long transient GCM runs
- Capable of producing daily output

Fundamental Differences
- CA uses daily GCM data; BCSD uses monthlyClimate
- BCSD (like a "MOS" type forecast) relates GCM output directly to observations, explicitly correcting for systematic GCM biases based on historic GCM performance
- CA corrects mean bias (using anomalies) but not spatial GCM biases
- Variability biases

Observational Baseline
- CA and BCSD are compared in hydrologic model output driven by gridded observed meteorology from 1977-1999
- See Maurer and Hidalgo, 2008, for details on intercomparison

Surrogate GCM output: NCEP/NCAR Reanalysis

Best possible GCM since obs are assimilated
- High correlation between model and observations
- Full temporal daily and monthly data available
- 1950-1976 used to "train" downsampling
- CA: coarse data to fine (1/8° grid)
- BCSD: coarse reanalysis to fine (1/8° grid)

Hydrologic States: simulation of water storage in soil and snow pack

Comparing HYDROLOGIC SIMULATIONS WITH CA AND BCSD

Conclusions, part 1
- Mean, seasonal cycles and interannual variability of soil moisture is reasonably reproduced by both BCSD and CA
- End-of-season snow accumulation also appears to be plausibly reproduced by both BCSD and CA
- Where they differ from Observations (for example, April soil moisture in the Pacific Northwest), BCSD and CA tend to differ in similar ways
- Hydrologic states appear to be recovered well by either downscaling method

Streamflow statistics for 22 water years: 1978-1999

Streamflow Gauges Used in this Study

Conclusions, part 2
- Center timing, a feature driven by temperature more than precipitation, shows correspondence with observations for CA at more locations than for BCSD
- This reflects the successful translation of large-scale daily skill in Reanalysis temperatures by CA
- For precipitation-driven daily statistics of low and high flows, BCSD shows correspondence with observations at more locations than CA
- The differences in precipitation-driven differences could be explained by:
  - Random resampling of daily sequences in BCSD may bear more resemblance to observations than large-scale CA’s daily downscaled Reanalysis anomalies

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References