An automated statistical downscaling approach for hydrologically-based climate-change studies across the nation

Christian Ward-Garrison and Lauren Hay

Integrated watershed scale response to global change in selected basins across the United States

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16 basins from different hydroclimatic regions selected as study sites.

- GCM climate change scenarios used as drivers to evaluate hydrologic responses using PRMS (Precipitation Runoff Modeling System – a physically based distributed watershed model).
- Integrated watershed scale response to global change in selected basins across the United States.
- Long term goal is to provide the foundation for hydrologically-based climate change studies across the nation.

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A PRMS model exists for each of these basins. Need future estimates of daily precipitation and maximum and minimum temperature at the station locations used in each of these PRMS models.
Methodology for Assessing Climate Change

**DOWNSCALING**

- Generating climate information below the grid scale of the GCMs
- Necessary due to large systematic biases and the poor skill present in GCM precipitation and temperature estimates

**Dynamical Downscaling**

*uses high-resolution regional climate models with boundary conditions from lower-resolution GCM data.*

**Statistical Downscaling**

*statistical post-processing of GCM data*
"Simple statistical downscaling methods seem to perform as well as more sophisticated methods in reproducing mean characteristics; if the downscaling of mean climate is the main objective then the effort required to use more sophisticated techniques is probably not warranted by the additional downscaling skill provided."

(Fowler et al., 2007, "Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modeling", Int. J. Climatol.)

Simplest is to apply GCM-scale projections in the form of Climate Change Fields.

GCM scale

Basin scale

Statistical Downscaling
Methodology for Assessing Climate Change

Statistical Downscaling

Derived by calculating the change in climate from present to future conditions simulated by each GCM.


Climate change fields (% changes in precipitation and degree changes in temperature) computed for monthly 12-year moving periods using GCM current and future conditions.

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Methodology for Assessing Climate Change
GCM Simulations

Data Availability Summary (as of 16 July 2007)

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Availability</th>
</tr>
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<tbody>
<tr>
<td>time-independent land surface</td>
<td>&gt;1</td>
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<tr>
<td>monthly-mean atmosphere</td>
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<td>3-hourly atmosphere</td>
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</tr>
<tr>
<td>time-independent ocean</td>
<td>&gt;1</td>
</tr>
<tr>
<td>monthly-mean ocean</td>
<td>1</td>
</tr>
</tbody>
</table>

- GCMs with precipitation, maximum temperature, and minimum temperature available for download on a monthly time step
  1. BCC-BCM2.0 -- Bjerknes Centre for Climate Research, Norway
  2. CCSM3 -- National Centre for Atmospheric Research, USA
  3. CSIRO-Mk3.0 -- Australia's Commonwealth Scientific and Industrial Research Org., Australia
  4. CSIRO-Mk3.5 -- Australia's Commonwealth Scientific and Industrial Research Org., Australia
  5. INM-CM3.0 -- Institute for Numerical Mathematics, Russia
  6. MIROC3.2(medres) -- National Institute for Environmental Studies, Japan

GCM grid-cell resolutions

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Data Availability Summary (as of 16 July 2007)

Shaded area indicates that at least some but not necessarily all fields are available for data type indicated:
- Time-independent land surface
- Monthly-mean atmosphere
- Daily-mean atmosphere
- 3-Hourly atmosphere
- Time-independent ocean
- Monthly-mean ocean
- Forcing
- Extreme Indices
- ISCCP Simulator

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<tr>
<th>Data Type</th>
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<th>Commit</th>
<th>SRESA2</th>
<th>SRESA1B</th>
<th>SRESB1</th>
<th>1%to2x</th>
<th>1%to4x</th>
<th>Slab cntl</th>
<th>2xCO2</th>
<th>AMIP</th>
</tr>
</thead>
</table>

**Scenarios in the IPCC Special Report on Emissions Scenarios**

**20C3M** -- represents the IPCC SRES climate of the 20th century

**SRESA2**: very heterogeneous world with high population growth, slow economic development and slow technological change.

SRESA1: assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. A1 is divided into 3 groups:

1. fossil intensive (A1FI),
2. non-fossil energy resources (A1T)
3. balance across all sources (SRESA1B).

**SRESB1**: a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.
Methodology for Assessing Climate Change

PRMS was run with daily current inputs (1989-2000) modified by the monthly climate change fields derived from the GCMs for monthly 12-year moving periods starting in 2001 and ending in 2099.

3 Future Scenarios x 6 GCMs x 88 input files = 1584 simulations/basin
GCM Output Access

Tool for downscaling precipitation and temperature from GCMs for hydrologic modeling
3 Future Scenarios x 6 GCMs x 88 input files = 1584 input files/basin
Previously calibrated PRMS models using climate station data as input
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Welcome to the Downsizer!
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