NARCCAP Multi-Model Simulations: Initial NCEP-Driven Results

Bill Gutowski, Ray Arritt, Gene Takle, Dave Flory, John Baranick (Iowa State University) and The NARCCAP Modelers Team
NARCCAP Participants

• Raymond Arritt, David Flory, William Gutowski, Gene Takle, Iowa State University, USA
• Richard Jones, W. Moufouma-Okia, Hadley Centre, UK
• Daniel Caya, Sébastien Biner, OURANOS, Canada
• David Bader, Phil Duffy, Lawrence Livermore National Laboratories, USA
• Filippo Giorgi, Abdus Salam ICTP, Italy
• Isaac Held, NOAA Geophysical Fluid Dynamics Laboratory, USA
• René Laprise, Univ. de Québec à Montréal, Canada
• Ruby Leung, Y. Qian, Pacific Northwest National Laboratories, USA
• Linda Mearns, Don Middleton, Doug Nychka National Center for Atmospheric Research, USA
• Ana Nunes, John Roads, Scripps Institution of Oceanography, USA
• Steve Sain, Univ. of Colorado at Denver, USA
• Lisa Sloan, Mark Snyder, Univ. of California at Santa Cruz, USA
Comparison with observations

- **Observations**
  - Precip: University of Washington VIC retrospective analysis
  - 500 hPa Heights: North American Regional Reanalysis

- **Comparison period: 1980-1999**
  - 1979 omitted - (a) spinup (b) WRFP began 1 Sep 79
  - UW data end in mid-2000

- **Analyses: monthly mean precipitation & 500 hPa Z**
  - Fields received at Iowa State for format check
  - For several regions in the U.S. (UW analysis extends to ~ 53°N)
Regions Analyzed

- Great Basin
- Coastal California
- Arizona - New Mexico
- Upper Mississippi River
- Corn Belt
- Deep South
- Ohio Valley
Coastal California

- Mediterranean climate: wet winters and dry summers (Koeppen types Csa, Csb)
- ENSO can have strong effects on interannual variability of precip
Monthly Time Series - Coastal CA

Monthly precipitation for coastal California

- RCM3
- ECPC
- Observed (UW)
- MM5I
- MRCC
- Ensemble Mean

1982-83 El Nino

multi-year drought

1997-98 El Nino
### Time Series Correlations - Coastal CA

<table>
<thead>
<tr>
<th>Model</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCM3</td>
<td>0.946</td>
</tr>
<tr>
<td>MM5I</td>
<td>0.946</td>
</tr>
<tr>
<td>ECPC</td>
<td>0.966</td>
</tr>
<tr>
<td>MRCC</td>
<td>0.959</td>
</tr>
<tr>
<td>Ensemble</td>
<td>0.968</td>
</tr>
</tbody>
</table>

Monthly precipitation for coastal California

- **RCM3**
- **MM5I**
- **ECPC**
- **MRCC**
- **Observed (UW)**
- **Ensemble Mean**
Further Statistics - Coastal CA

Mean annual cycle, coastal California:
- RCM3
- MM5I
- ECPC
- MRCC
- Obs (UW)
- Ensemble

Monthly mean precipitation, mm/day:
- Observed
- Ensemble mean
1997-1998 El Niño

- Strongest El Niño in the instrumental record.
October 1997

RegCM3

MRCC

Observed (CRU)

RSM

MM5
January 1998

RegCM3

MRCC

Observed (CRU)

RSM

MM5
March 1998

RegCM3

MRCC

Observed (CRU)

RSM

MM5
Circulation with Extreme Precipitation

Precip. Max.: Feb 1998
Simulated Circulation with Extreme Precipitation
Deep South

- Humid mid-latitude climate with little seasonality in precip amount (Koeppen type Cfa).
- Past studies have found problems with RCM simulations of cool-season precip in this region.
Monthly Time Series - Deep South

Monthly precipitation for Deep South

- RCM3
- ECPC
- Observed (UW)
- MM5I
- MRCC
- Ensemble Mean
### Time Series Correlations - Deep South

<table>
<thead>
<tr>
<th>Model</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCM3</td>
<td>0.257</td>
</tr>
<tr>
<td>MM5I</td>
<td>0.377</td>
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<tr>
<td>ECPC</td>
<td>0.636</td>
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<tr>
<td>MRCC</td>
<td>0.645</td>
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<tr>
<td>Ensemble</td>
<td>0.597</td>
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<tr>
<td>Ensemble of MRCC and ECPC</td>
<td>0.709</td>
</tr>
</tbody>
</table>

ECPC and MRCC both incorporate large-scale information in the domain interior: ECPC is a perturbation model (RSM), while MRCC uses spectral nudging.
Further Statistics - Deep South

Mean annual cycle, Deep South

- RCM3
- MM5I
- ECPC
- MRCC
- Obs (UW)
- Ensemble

too dry in the cool half of the year

Monthly mean precipitation, mm/day

high rates (> 4 mm/day) are underpredicted
Circulation with Extreme Precipitation

Precip. Max.: April 1991
Simulated Circulation with Extreme Precipitation
Comments and speculations

• A simple unweighted ensemble mean usually performs better than the best individual model, or close to the best model when spread is large.

• Hypothesis: Downscaling of ENSO could be an especially suitable use for a coupled GCM-RCM:
  • RCMs perform well in coastal California during ENSO
  • Some AOGCMs can produce reasonable ENSO (see e.g., Van Oldenborgh et al. 2005).
  • Two of these AOGCMs are used in NARCCAP: GFDL CM2.1 and HadCM3.
Comments and speculations

• Incorporation of large-scale information into the RCM (whether through spectral nudging or use of a perturbation form of the governing equations) appears to be an advantage for the Deep South region.
  • This advantage does not carry over to other regions (or is outweighed by other factors, e.g., model physics).
5-Yr Return Period Amounts
[mm/day]

OBSERVATIONS
1980-1999

Thanks to Hayley Fowler for diagnostic code
5-Yr Return Period Amounts

[mm/day]
Thank You

Further Information

1. General: http://www.narccap.ucar.edu


3. Data portal: http://esg.ucar.edu/forward.htm?forward=narccap
U.S. Corn Belt

• Western part is a continental climate with warm summers and cold winters becoming less continental to the east. (Koeppen types Dfa, Dfb)

• Maximum precipitation in April-June
  • seasonality of precip is important for agriculture, e.g., drawdown of soil moisture during the growing season

• Includes the Upper Mississippi River basin
### Monthly precipitation, U.S. Corn Belt region

- **RCM3**: 0.722
- **MM5I**: 0.692
- **ECPC**: 0.636
- **MRCC**: 0.760
- **Ensemble**: 0.788

#### Model Correlation

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>RCM3</td>
<td>0.722</td>
</tr>
<tr>
<td>MM5I</td>
<td>0.692</td>
</tr>
<tr>
<td>ECPC</td>
<td>0.636</td>
</tr>
<tr>
<td>MRCC</td>
<td>0.760</td>
</tr>
<tr>
<td>Ensemble</td>
<td>0.788</td>
</tr>
</tbody>
</table>

#### Time Series

- **1988 drought**
- **1993 flood**
Mean annual cycle, Corn belt

- RCM3
- MM5
- ECPC
- MRCC
- Obs (UW)
- Ensemble

low rates (< 2 mm/day) are overpredicted

too wet in winter/spring

too dry in summer

Monthly mean precipitation, mm/day

high rates (> 4 mm/day) are underpredicted
Upper Mississippi River Basin

- Continental climate with warm summers and cold winters (Koeppen types Dfa, Dfb).
- Maximum precipitation in April-June:
  - seasonality of precip is important for impacts, e.g., drawdown of soil moisture during the growing season
- Most NARCCAP models simulated this region in the PIRCS project.
Monthly precipitation, Upper Mississippi River basin

<table>
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<tr>
<td>RCM3</td>
<td>0.745</td>
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<td>MM5I</td>
<td>0.696</td>
</tr>
<tr>
<td>ECPC</td>
<td>0.627</td>
</tr>
<tr>
<td>MRCC</td>
<td>0.779</td>
</tr>
<tr>
<td>Ensemble</td>
<td>0.791</td>
</tr>
</tbody>
</table>

1988 drought

1993 flood
Mean annual cycle, Upper Mississippi River basin

- RCM3
- MM5I
- ECPC
- MRCC
- Obs (UW)
- Ensemble

low rates (< 2 mm/day) are overpredicted

Monthly mean precipitation, mm/day

high rates are underpredicted
1982-1983 and 1997-98 El Niños

- Some AOGCMs give realistic simulation of ENSO:
  - see e.g., van Oldenborgh et al. (2005, Ocean Science) for IPCC AR4 models

- Do regional models give realistic precipitation during El Niño events?
  - If so, perhaps a combined AOGCM-RCM approach can give useful results for ENSO in future climates.

October 1982

RegCM3

MRCC

Observed (CRU)

RSM

MM5

Legend: 0.5 - 1 - 2 - 4 - 6 - 8 - 12
February 1983

RegCM3

MRCC

Observed (CRU)

RSM

MM5
April 1983

RegCM3

MRCC

Observed (CRU)

RSM

MM5
1993 flood in the north-central U.S.

- The event mainly was the result of synoptic-mesoscale dynamics with little direct influence by terrain.
- This event was the subject of an early regional model intercomparison which performed 60-day simulations (PIRCS, 1B).
Summer 1993 flood in central U.S.

RegCM3

MRCC

July 1993 precipitation

Observed (CRU)

• model skill is very similar to PIRCS 1B

RSM

MM5
5-Yr Return Period Amounts [mm/day]
5-Yr Return Period Amounts [mm/day]