Regional Climate Model Projections for the North American Monsoon

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Project Goals

• Examine credibility of an ensemble of RCM simulations and their projections for the North American Monsoon System (among others).

• Establish the differential credibility of the RCM/GCM combinations.

• Extend analysis beyond temperature and precipitation and the use of basic metrics.
  – Establish whether or not the processes that make up the monsoon system are credibly simulated.

• Identify bias in monsoon processes and establish the potential impact of that bias on projections.
ENSEMBLE MEAN CHANGE: Precipitation
1971-1999 vs. 2041-2069 Months: 06,07,08,09

Agreement: on sign of projection.

9/9 agree on drying
6/9 agree on drying

9 RCM
JJAS
Mean Change
Other Datasets

• For comparison:

  – **NARR** (North American Regional Reanalysis), **32-km** horizontal resolution.
  – **UDEL** (University of Delaware), **½ degree** resolution, gridded observations, for land only.
  – **NAME** (North American Monsoon Experiment), **1 degree** resolution, gridded observations from a special observing period during July 2004
THE NORTH AMERICAN MONSOON SYSTEM
**SOUTHWEST OROGRAPHY**

Left: 2.0° x 2.5°
Bottom Left: 50km
Bottom Right: 10km

(m)

(0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000)
Fig. 2. Seasonal distribution of precipitation across southwestern North America. Note that northwestern Mexico shows the strongest monsoon signal, which diminishes through Arizona, New Mexico, and Nevada. Northeastern Mexico and Texas display early summer–late fall precipitation peaks, while the West Coast has a dry summer Mediterranean distribution (vertical axis of all graphs represents 180 mm with 20 mm increments). Areas south of the broken line receive greater than 50% of their annual rainfall in July, August, and September (after Douglas et al. 1993).
Verification Part 1

REANALYSIS DRIVEN SIMULATIONS
10m Wind: Annual Cycle

NARR: JAN

NARR: JUL

(m/s)
1980-2004 JJAS Average Near-Surface Moisture Flux
1980-2004 JJAS Average Precipitation Rate
Precipitation Bias (vs. UDEL): 1980-2004 JJAS
1980-2004 5-day Average Precipitation Climatology
NCEP-Driven Simulations

![Graph showing precipitation climatology over 1980-2004 with various models compared.](image-url)
1980-2004 5-day Average Precipitation Climatologies: AZ Only
JJAS Average Sounding

The diagram shows temperature (°C) on the x-axis and pressure (hPa) on the y-axis. Various lines represent different models and observations, including NARR, CRCM, HRM3, MM5I, RCM3, and WRFG. The inset map provides a geographical context for the data.
Verification Part 2

CURRENT GCM DRIVEN SIMULATIONS
1971-1999 JJAS Near-Surface Moisture Flux: GCM-driven
(NARR 1980-2004)
1971-1999
JJAS
Average Precipitation
5-day Average Precipitation Climatology
5-day Average Precipitation Climatology
Why do the CGCM and CCSM driven simulations not capture the monsoon signal in precipitation?

850mb Specific Humidity
JJAS 1971-1999

(g/kg)
JJAS Average Sounding

Graph showing temperature (°C) against pressure (hPa) with lines representing different models such as NARR, CRCM-ccsm, and WRFG-ccsm.
What might be causing the excessive late season precipitation in the GFDL-driven simulations?
850 hPa Specific Humidity

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2m Temperature Over Water
700hPa NARR & gfdl2 1 1980 to 1999: mons 08

gfdl2 1 Contour from 3130 to 3190 by 10
NARR Contour from 3070 to 3200 by 10
700hPa NARR & gfdl2 1 1980 to 1999: mons 09

gfdl2 1 Contour from 3110 to 3170 by 10
NARR Contour from 3010 to 3180 by 10
FUTURE GCM DRIVEN SIMULATIONS
ENSEMBLE MEAN CHANGE: Precipitation

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9 RCM
JJAS
Mean Change
2041-2069 : 1971-1999
JJAS
Average Precipitation
Percent Difference

Hatching indicates statistically significant changes at the 0.1 level. Method = bootstrapping.
CRCM_ccsm
CRCM_cgcm
MM5I_ccsm

RCM3_gfdl
RCM3_cgcm
WRFG_ccsm
WRFG_cgcm

shading = change in magnitude is significant at the 0.1 level

2041-2069 : 1971-1999 JJAS
Near-Surface Moisture Flux Difference
Final Comments

• The ability of the models to capture monsoon system rainfall is heavily determined by driving GCM.

• Bias in near surface moisture flux/wind fields is heavily determined by the RCM.

• Future work will include examining the driving GCMs to determine, more specifically, how they are influencing the RCMs in terms of their ability to simulate a monsoon system and in terms of their influence on the RCM projections. Additional RCM analysis will follow.

• Clearly, for this region, this will be an interesting ensemble of models to work with for this process-based credibility analysis. The projections may be similar, but the differences in the RCMs and GCMs are striking.