Regional, Extreme Daily Precipitation in NARCCAP Simulations

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The North American Regional Climate Change Assessment Program (NARCCAP)

Objectives:

- Investigate systematically the uncertainties in regional-scale projections of future climate
- Produce high resolution climate-change scenarios using
  - multiple regional climate models (RCMs)
  - nested within atmosphere ocean general circulation models (AOGCMs)
  - forced with the A2 SRES scenario
  - and using a common domain.

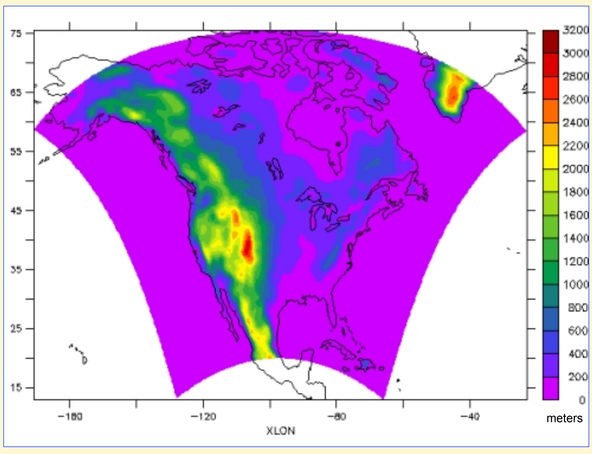
GOALS OF THIS WORK

1. Compare simulated vs. observed extreme daily precipitation
2. Compare simulated vs. observed processes producing extreme precipitation
3. Set foundation for evaluating changes in extreme precipitation under global warming

NARCCAP

NARCCAP Simulations: NCEP-Driven

- **Domain:**
  Most of North America
- **Simulation Period:**
  1978-2004
- **Boundary Conditions:**
  NCEP/DOE reanalysis



MODELS

1. Canadian Regional Climate Model Version 4 (designated CRCM in the NARCCAP archive),
2. Hadley Centre HadRM3 (HRM3 in the archive)
3. National Center for Atmospheric Research (NCAR) WRF (WRFG)
4. NCAR/Penn State MM5 (MM5I)
5. International Centre for Theoretical Physics RegCM3 (RCM3),
6. Experimental Climate Prediction Center's Regional Spectral Model (ECP2)
7. Geophysical Fluid Dynamics Lab Global Climate Model (GFDL)
8. NCAR Community Climate System Model (CCSM)

Models 1-6 are regional climate models (RCMs). The GFDL model is a global atmospheric climate model run in "time-slice" mode. The CCSM is a global atmosphere-ocean model analyzed for a period that nominally is the same as used by the other models.

The RCMs and the GFDL model used ~ 0.5˚ resolution.
The CCSM used ~1.4˚ resolution.

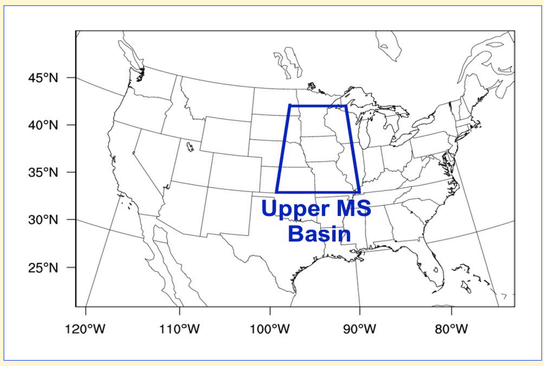
OBSERVATIONS

- Precipitation: Univ. Washington VIC Retrospective Analysis (0.5˚ grid)
- Other fields: North American Regional Reanalysis

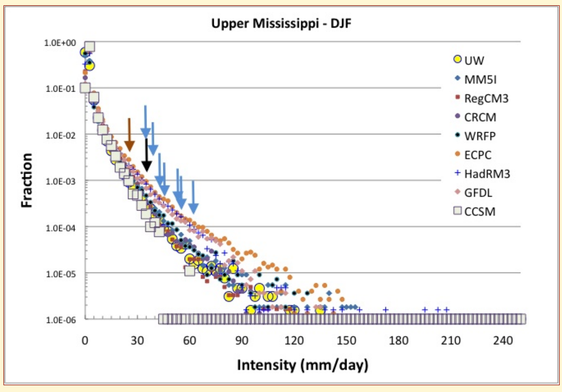
ANALYSIS

- **Period: 1982-1999**
  1979-1981 omitted for spin up
  UW data end in mid-2000
- **Precipitation "event" = Daily precip. > 0 @ grid point**
- **Focus on precip. intensity ≥ 99.5% level**
- **Target Region: Upper Ms Basin Box (right)**

This has been a study area for much of our NARCCAP research.



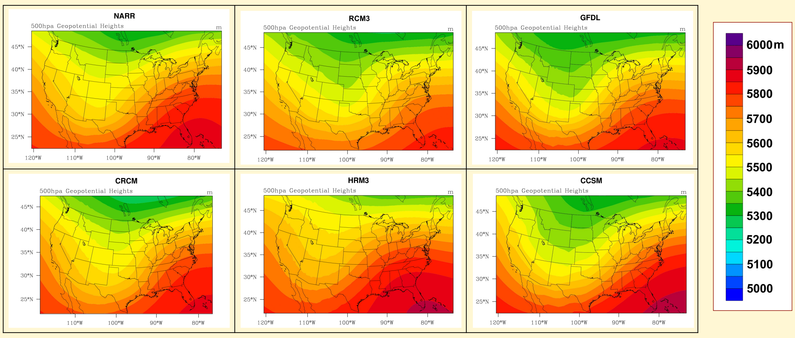
Results: Winter (Dec-Jan-Feb)



Precipitation Frequency vs. Intensity: Arrows mark the 99.5% level (Black = UW obs., Blue = 0.5˚ models, Green = CCSM).

The models reproduce well the frequency distribution, though some have more intense rain than the gridded observations. The CCSM has the lowest 99% level, and it does not produce the high intensity events.

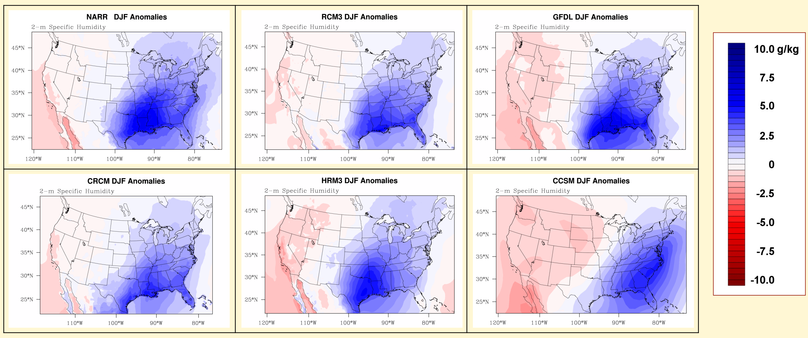
Composite 500 hPa Heights



500 hPa heights composited for days with extreme precipitation at 15 or more 0.5˚ grid points in the Upper MS box. These “widespread” events should involve resolved circulation. Composites shown for observed flow (NARR), 3 representative RCMs, the GFDL time-slice run and the CCSM AOGCM.

The models all replicate the general features of a deep trough to the west that promotes moisture transport from the Gulf of Mexico to the Upper MS box.

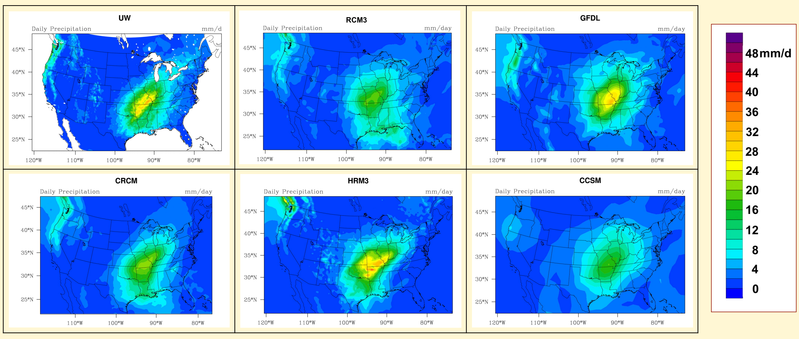
Composite 2-m Specific Humidity Anomalies



2-m specific humidity anomaly with respect to seasonal climatology, composited for days with “widespread” extremes. Composites shown for the same data sources as the composite 500 hPa heights.

The models generally replicate the observed feature of a positive humidity anomaly that is consistent with the transport implied by the 500 hPa flow. The coarser resolution CCSM has the anomaly farther east and does not show spatial details seen in the other sources.

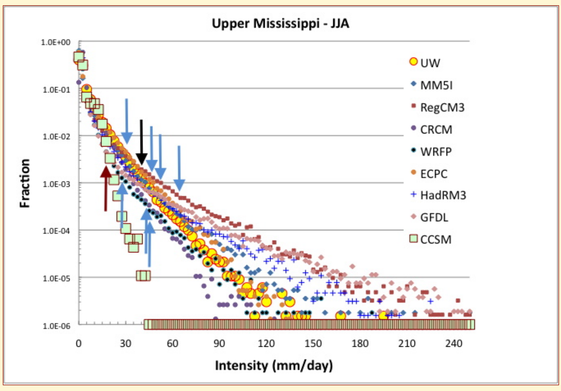
Composite Extreme Precipitation



Precipitation composited for days with “widespread” extremes. Composites shown for the same data sources as the composite 500 hPa heights, except precipitation comes from the gridded UW data set.

The models replicate the observed feature of a precipitation centered around the southeast corner of the Upper MS box, with patterns indicative of storms tracking northeastward along the edge of the deep trough. The coarser resolution CCSM lacks the spatial detail and intensity of the other sources.

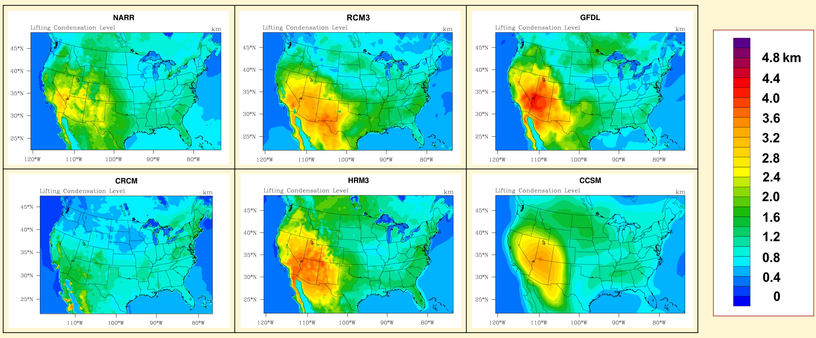
Results: Summer (Jun-Jul-Aug)



Precipitation Frequency vs. Intensity: Arrows Mark the 99.5% level (Black = UW obs., Blue = 0.5˚ models, Green = CCSM).

As with DJF, the models reproduce well the frequency distribution. Some have more intense rain than the gridded observations. The CCSM has the lowest 99% level, and does not produce the high intensity events.

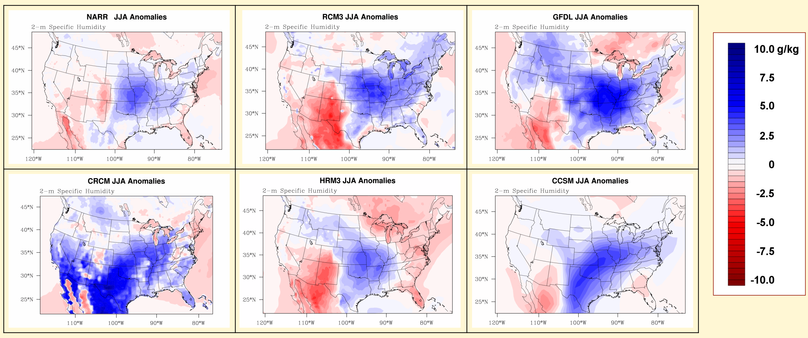
Composite Lifting Condensation Level



Lifting condensation level composited for days with extreme precipitation at 15 or more 0.5˚ grid points in the Upper MS box (“widespread” extremes). Composites shown for observed flow (NARR), 3 representative RCMs, the GFDL time-slice run and the CCSM AOGCM.

The models all replicate the general feature of relatively low LCL in the central Upper MS box, though magnitudes differ. The coarser CCSM has a smoother distribution and higher LCL in the Upper MS box.

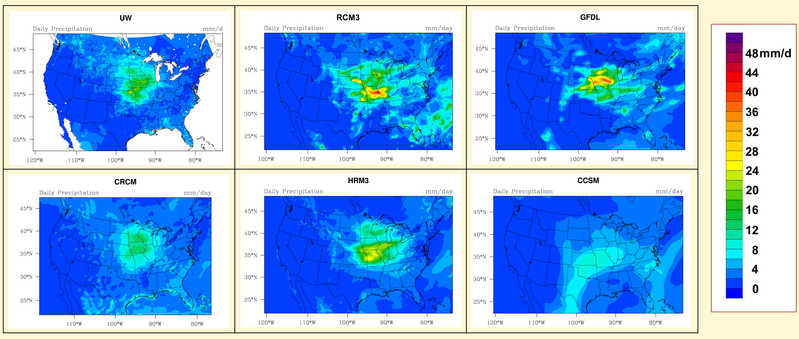
Composite 2-m Specific Humidity Anomalies



2-m specific humidity anomaly with respect to seasonal climatology, composited for days with “widespread” extremes. Composites shown for the same data sources as the composite LCL.

Most models replicate the observed feature of a positive humidity anomaly that is centered in the Upper MS box. The positive humidity anomaly in the central U.S. tends to align with low LCL.

Composite Extreme Precipitation



Precipitation composited for days with “widespread” extremes. Composites shown for the same data sources as the composite LCL, except precipitation comes from the gridded UW data set.

The models approximately replicate the observed feature of precipitation concentrated in the middle of the Upper MS box, though with widely varying maximum intensities. The alignment of low LCL and precipitation anomalies indicates that convective precipitation is (not surprisingly) an important process for extreme JJA precipitation in the Upper MS box in models as well as observations. As in DJF, the coarser resolution CCSM lacks the detail and intensity of the other sources.