Creating dynamically downscaled seasonal climate forecast and climate projection information for the North American Monsoon region suitable for decision making purposes

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ATMOSPHERIC SCIENCES
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Presentation Outline

Motivation

Regional climate modeling methodology

Warm-season seasonal climate forecasts and climate change projections

Consideration of extreme events

Conclusions

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Jae Schemm and Henry Juang (NCEP). Ed Cook and Russ Vose (NOAA). Matt Switanek (UA)

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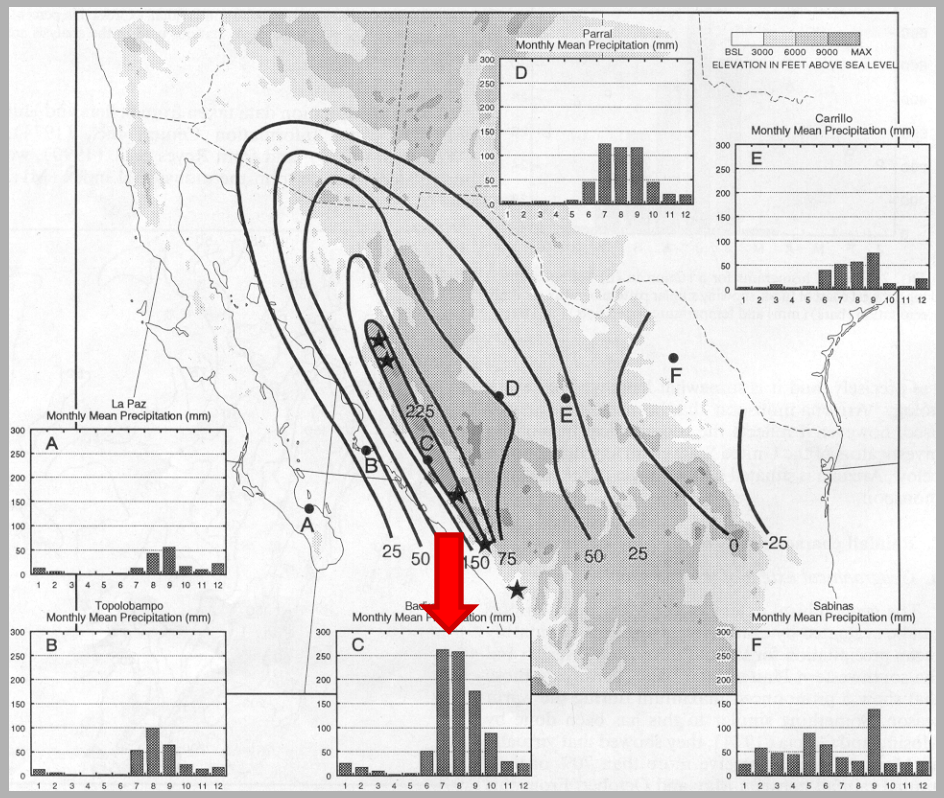
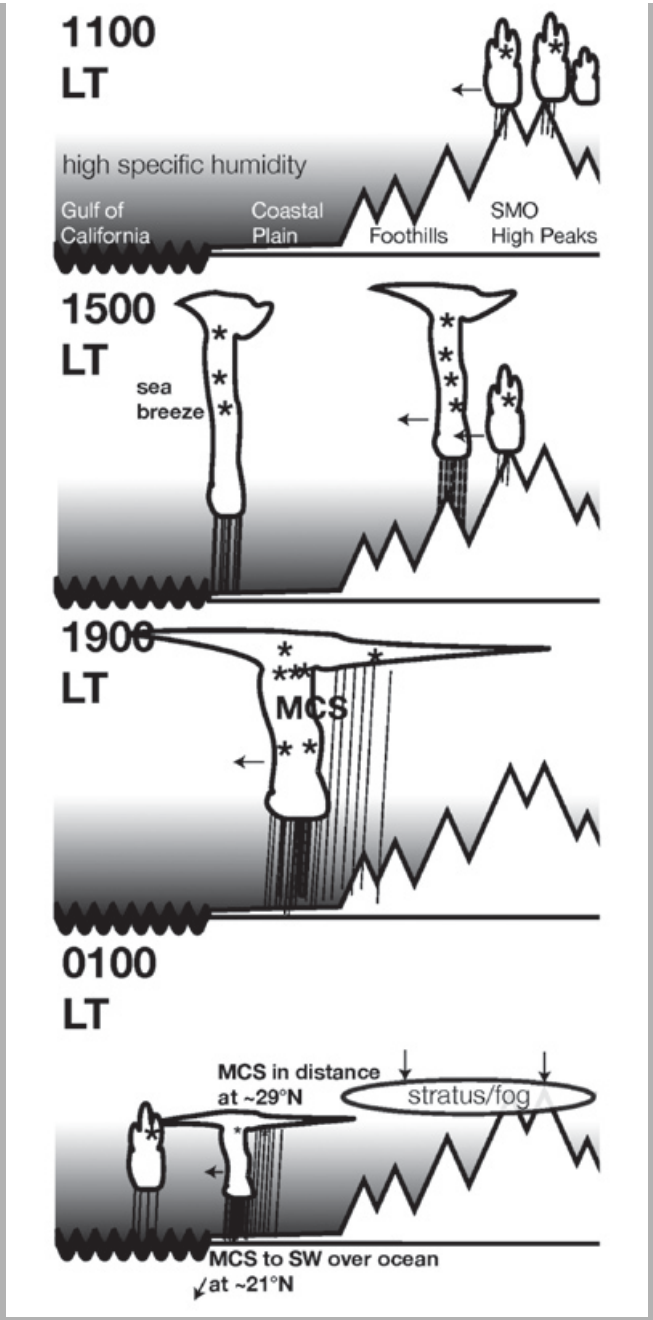
North American monsoon climatology:



Average rainfall in western Mexico during summer monsoon (Douglas et al. 1993)

- Monsoon is a seasonal maximum in precipitation in northwest Mexico that progresses into Southwest U.S.
- Characterized by a rapid increase in thunderstorm activity in early summer.



(Nesbitt et al. 2008)

Diurnal Cycle of Convection

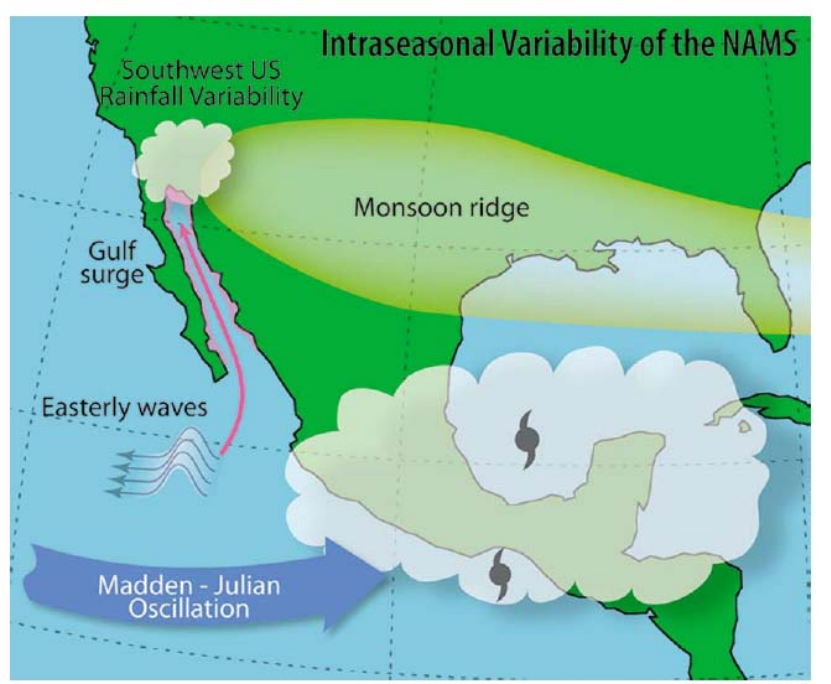
Crucial for Precipitation

Convective clouds form over the mountains in the morning.

By afternoon and evening storms propagate to the west towards the Gulf of California where they can organize into mesoscale convective systems if there is sufficient moisture and instability.

Intraseasonal variability

Helps convection organize and intensify



(Moloney et al. 2008)

Includes:

- **Easterly waves**
- **Tropical cyclones**
- **Low level moisture surges**
- **Upper level disturbances**
- **Madden Julian Oscillation**

Monsoon Interannual Variability
Remotely forced teleconnections and land surface feedback

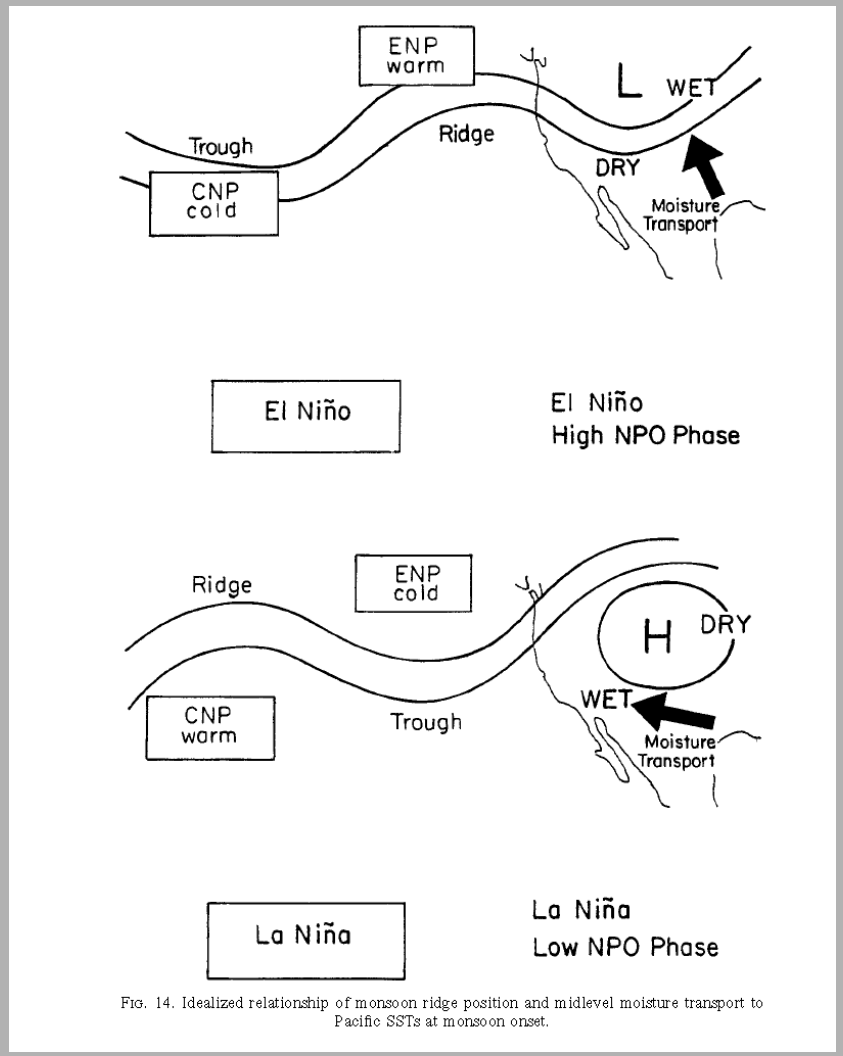


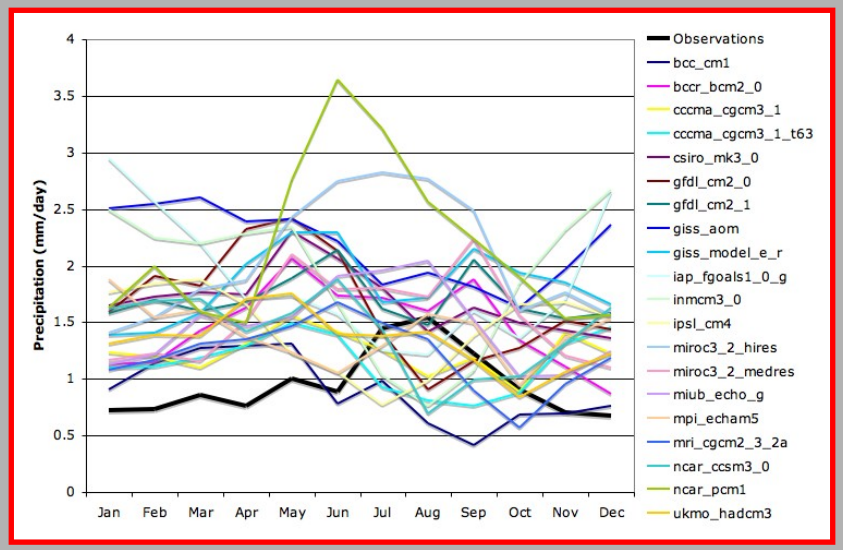
FIG. 14. Idealized relationship of monsoon ridge position and midlevel moisture transport to Pacific SSTs at monsoon onset.

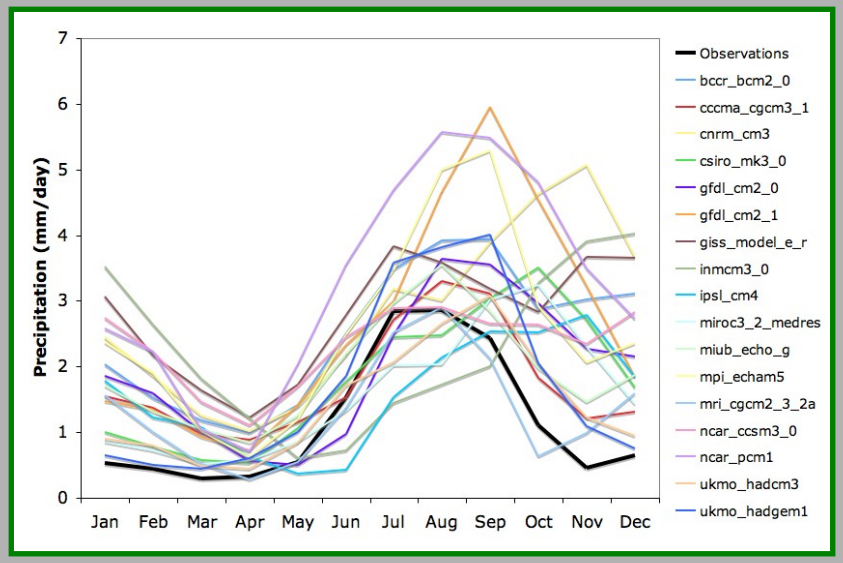
Climatology delayed

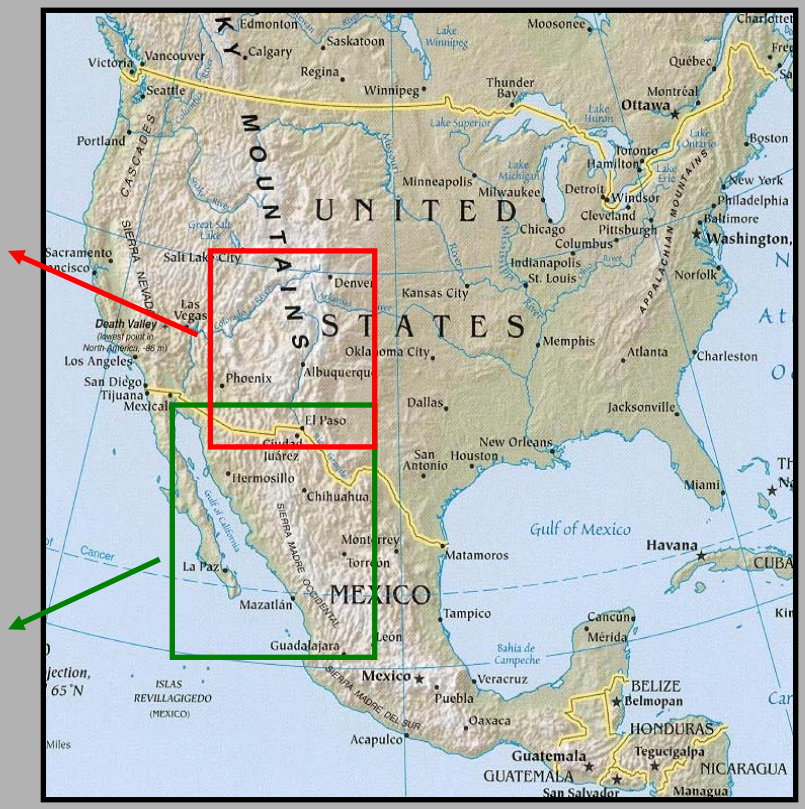
Climatology accelerated

(Castro et al. 2001)

Monthly average historical precipitation from IPCC models
Similar to CFS: very poor representation of monsoon



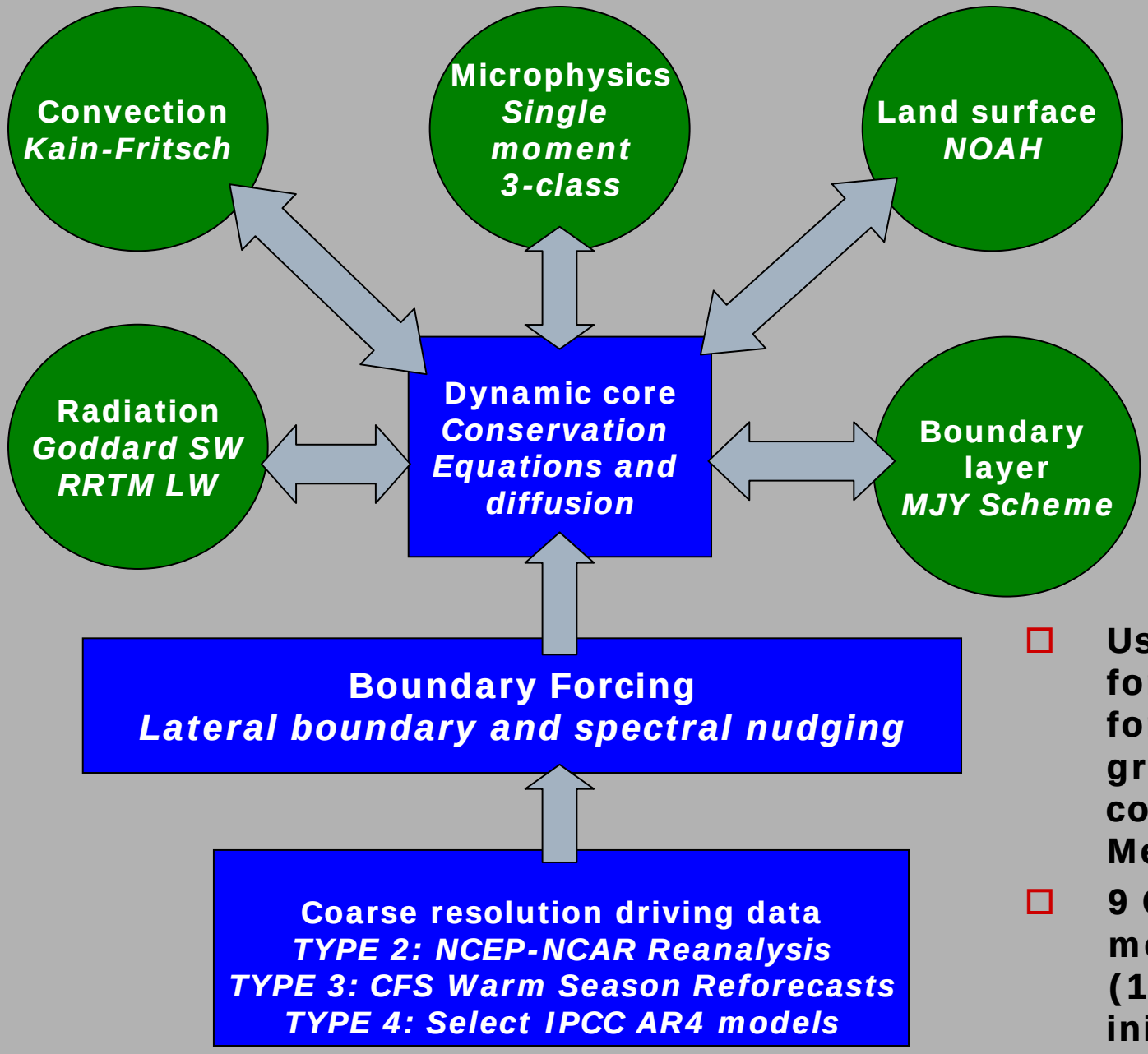




Historical average of simulations (sres_20c3m) 1970-2000

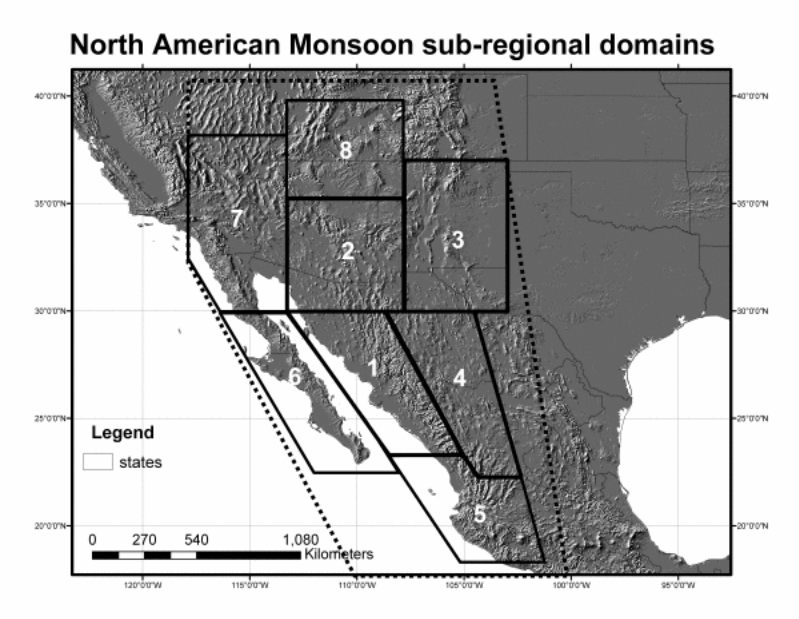
(Francina Dominguez)

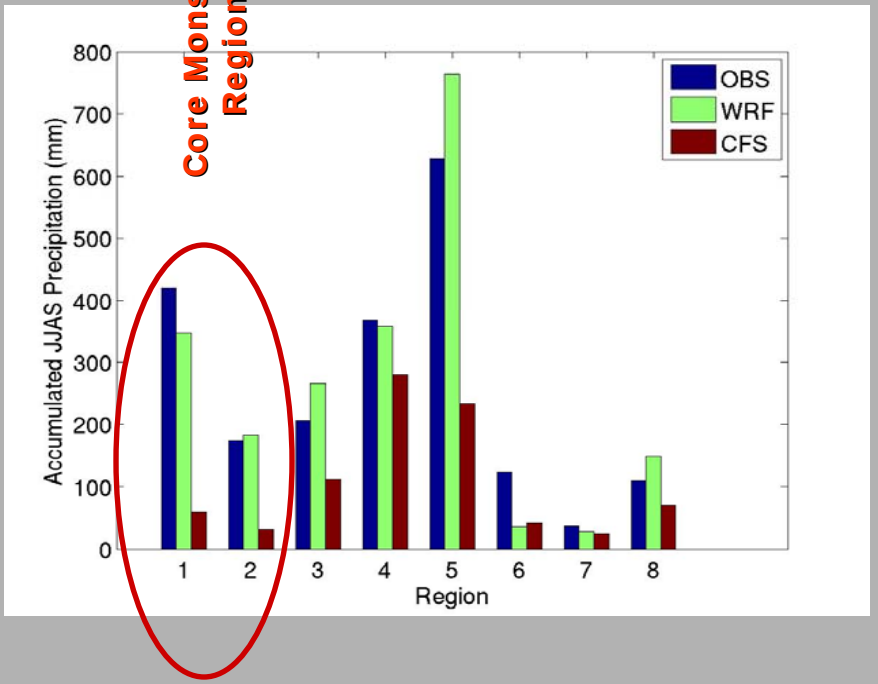
Dynamical Downscaling Methodology with WRF



- Use WRF configuration for UA operational forecasting at 32 km grid spacing over contiguous U.S. and Mexico
- 9 CFS ensemble members per season (1982-2000 Apr – Jun. initializations)

NAME Regions Monsoon Precipitation Climatology (JJAS): CPC gridded, global CFS, CFS-WRF downscaled

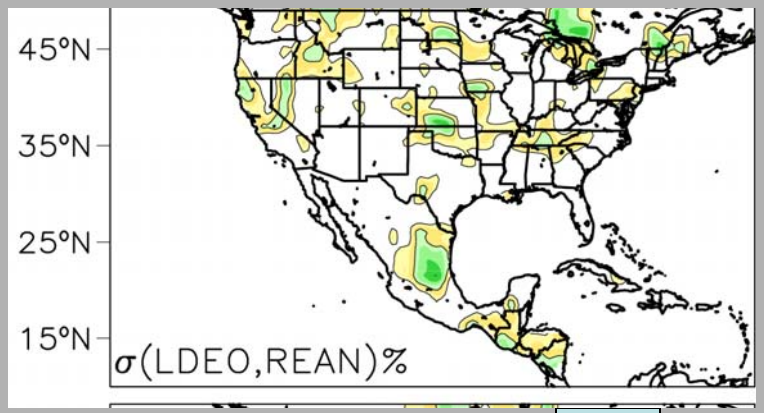




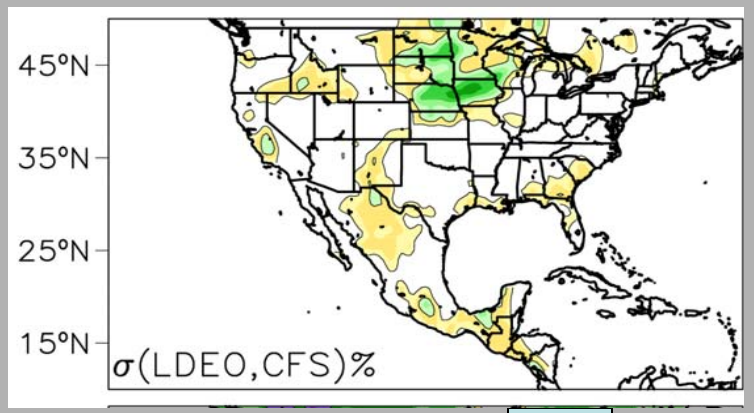
Dramatic improvement in the climatology of monsoon precipitation accounted for by a much better representation of the diurnal cycle of convection.

JJ SPI Anomaly Correlation: using new NOAA precipitation data product (similar to PRISM)

NCEP Reanalysis



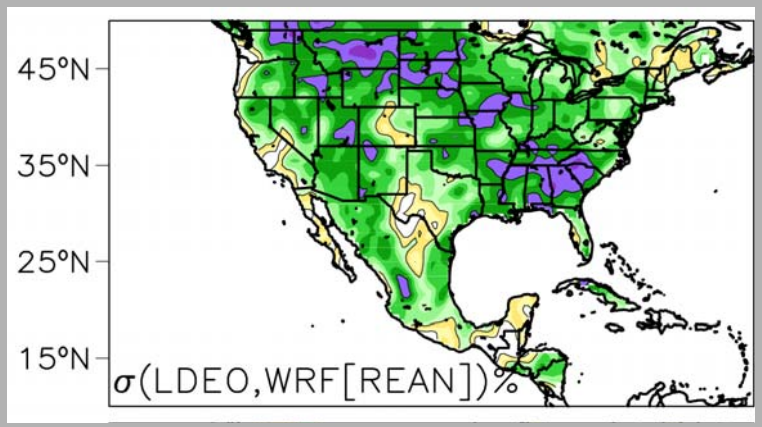
CFS model



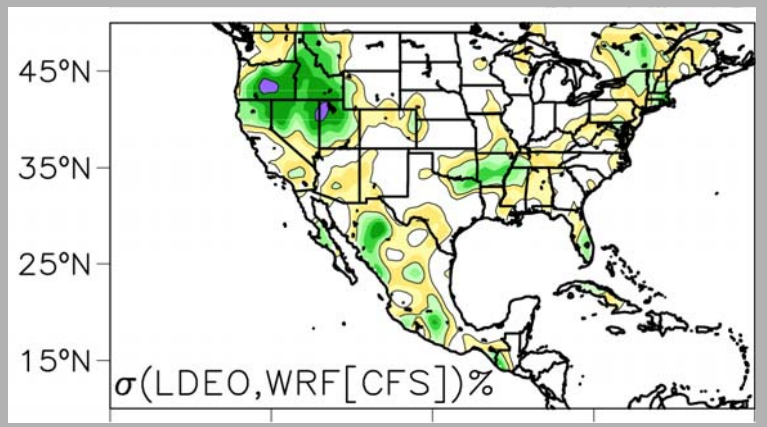
TYPE 2

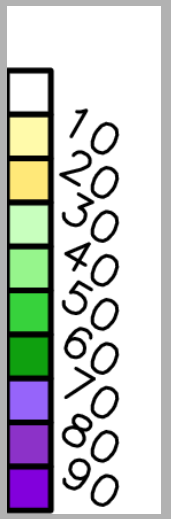
TYPE 3

WRF Downscaled NCEP Reanalysis

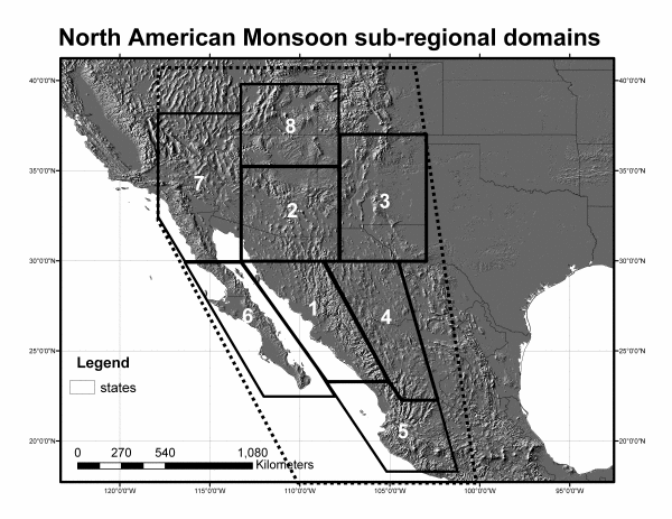


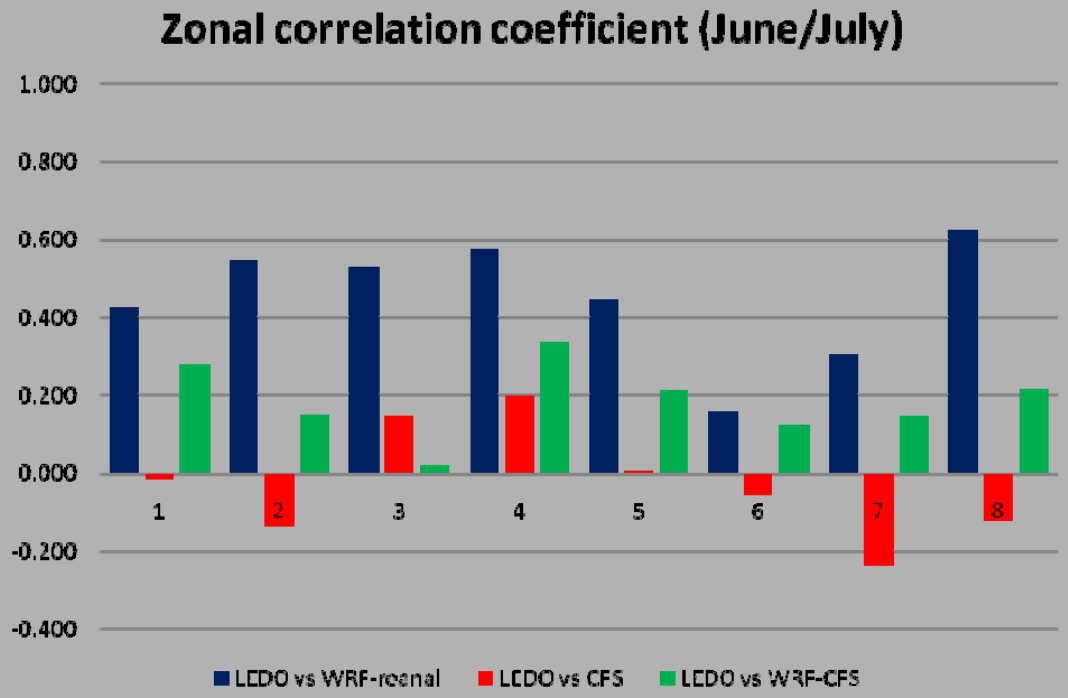
WRF Downscaled CFS model





Anomaly Correlation for NAME Regions: Standardized Precipitation Index Global and regional model data vs. obs.





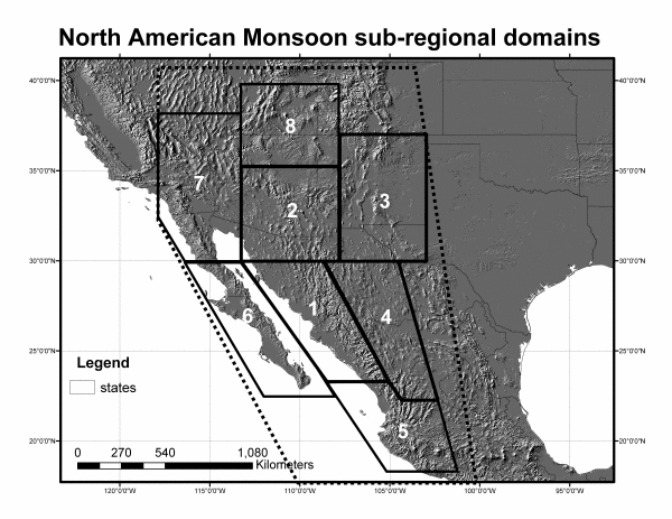
Hypothesis for value added: Best to worst performance should be

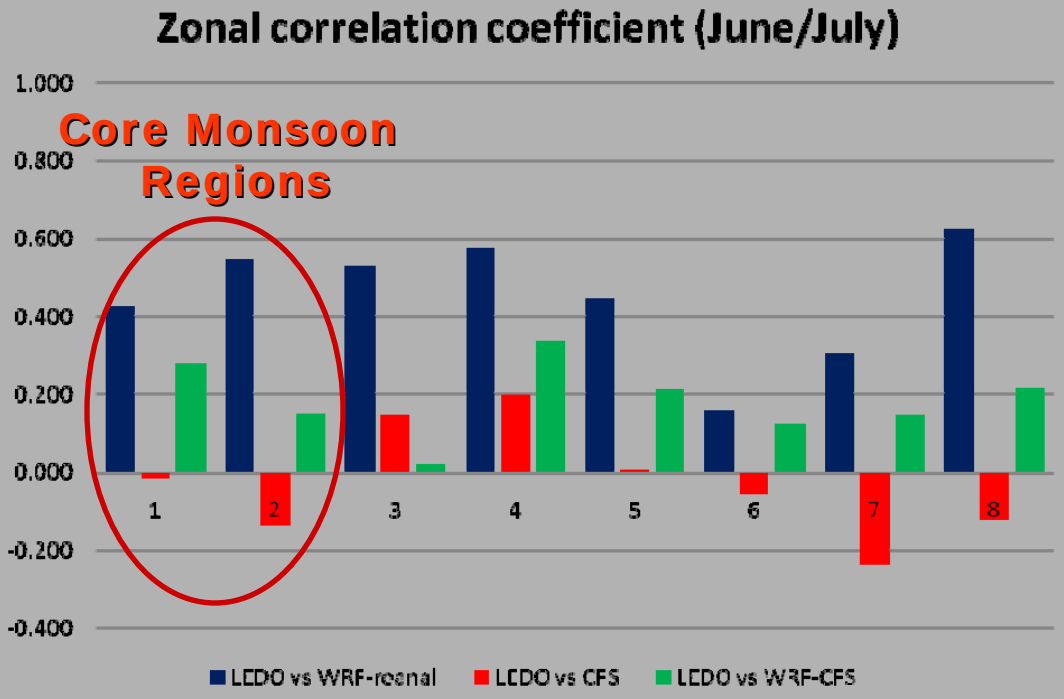
Reanalysis Downscaling: "Perfect LBC"

CFS-WRF Downscaled Seasonal Forecast

Original CFS global model data

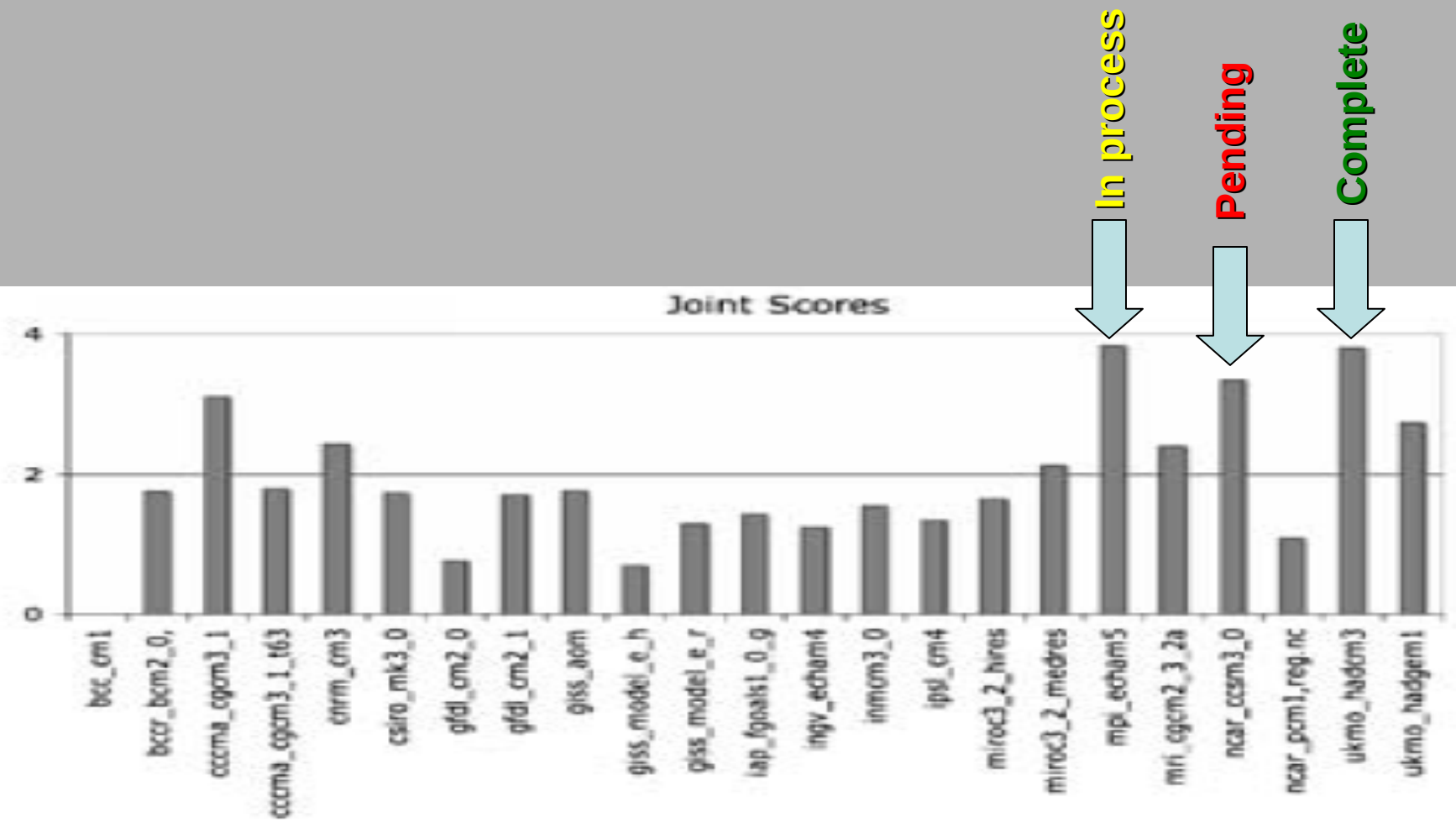
Anomaly Correlation for NAME Regions: Standardized Precipitation Index Global and regional model data vs. CPC obs.





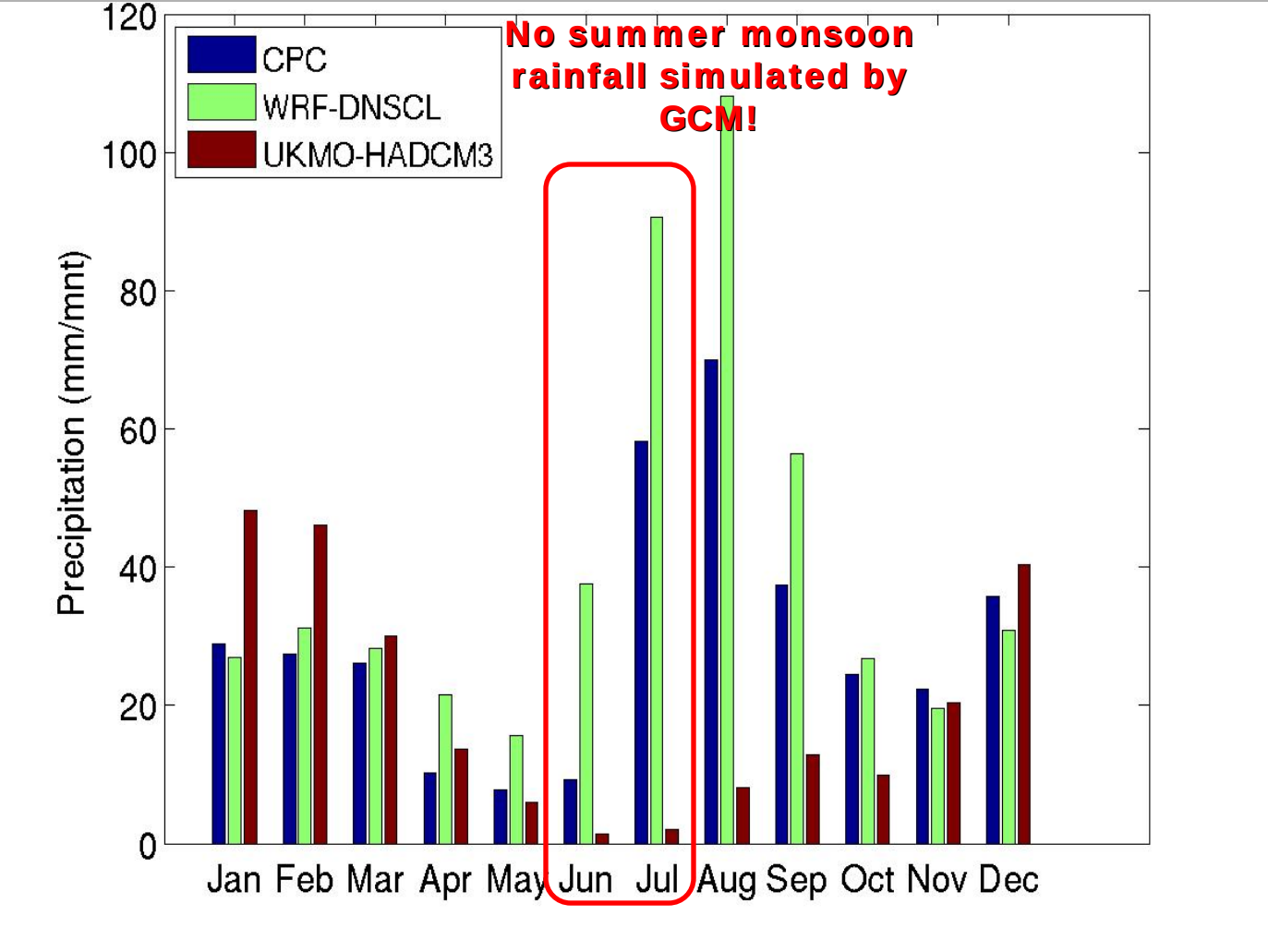
- Overall dynamical downscaling leads to improvement in early warm season seasonal forecast precipitation in the core monsoon region, especially in northern Mexico. Less impressive improvement for Arizona

“Well Performing” IPCC AR4 models for dynamical downscaling of A2 emission scenario (1967-2081)



Ranking of IPCC-AR4 models for Southwest U.S., based on similarity with historical data and convergence in the future (Dominguez et al. 2009)

Annual precipitation climatology for Arizona

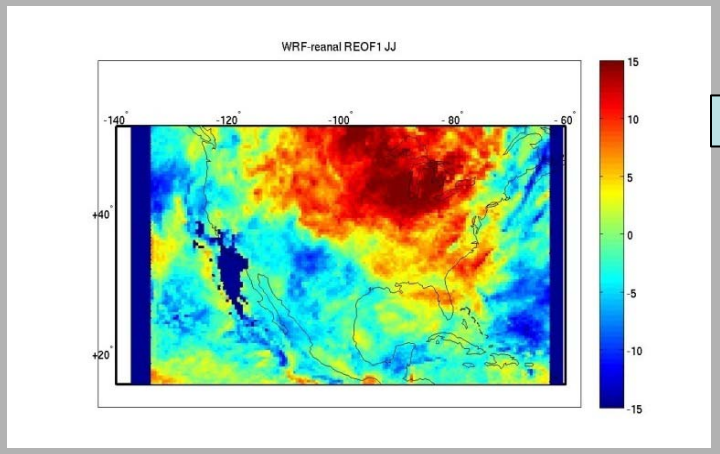


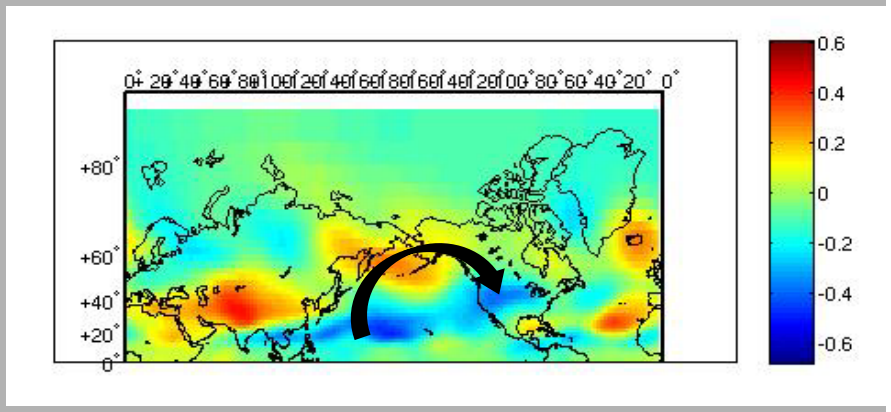
Dominant REOF of JJ downscaled SPI and relationship to 500-mb height anomalies (similar results for WRF-CFS downscaling)

Dominant Precipitation Mode

500-mb Height Anomaly

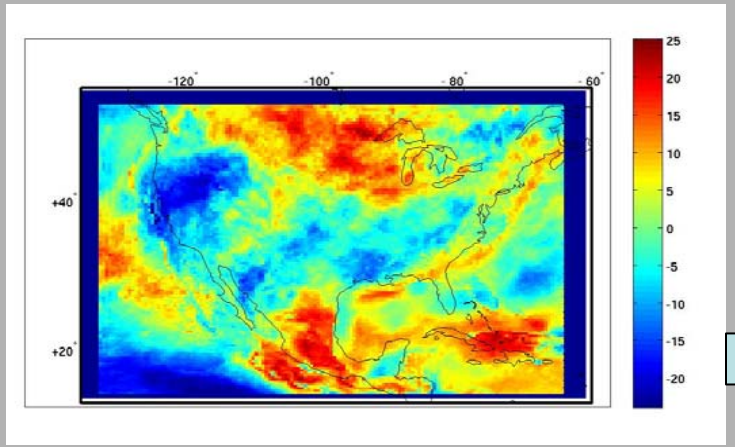
WRF-Reanalysis TYPE 2

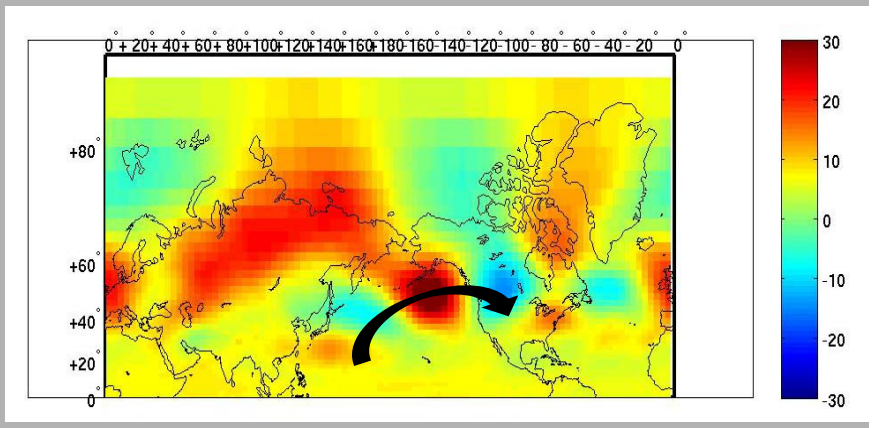




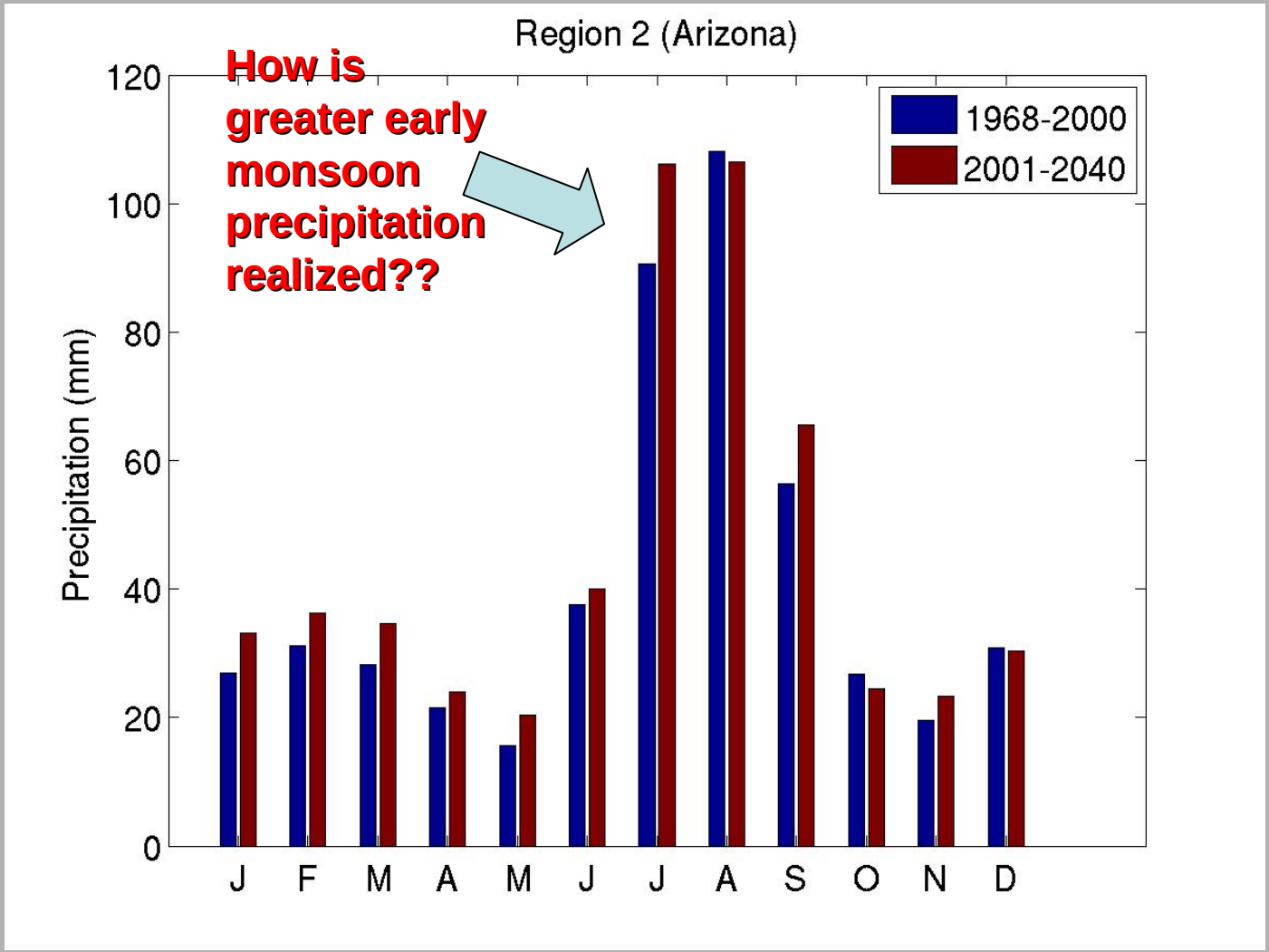
Principal Component Regression

WRF-HadCM3 TYPE 4



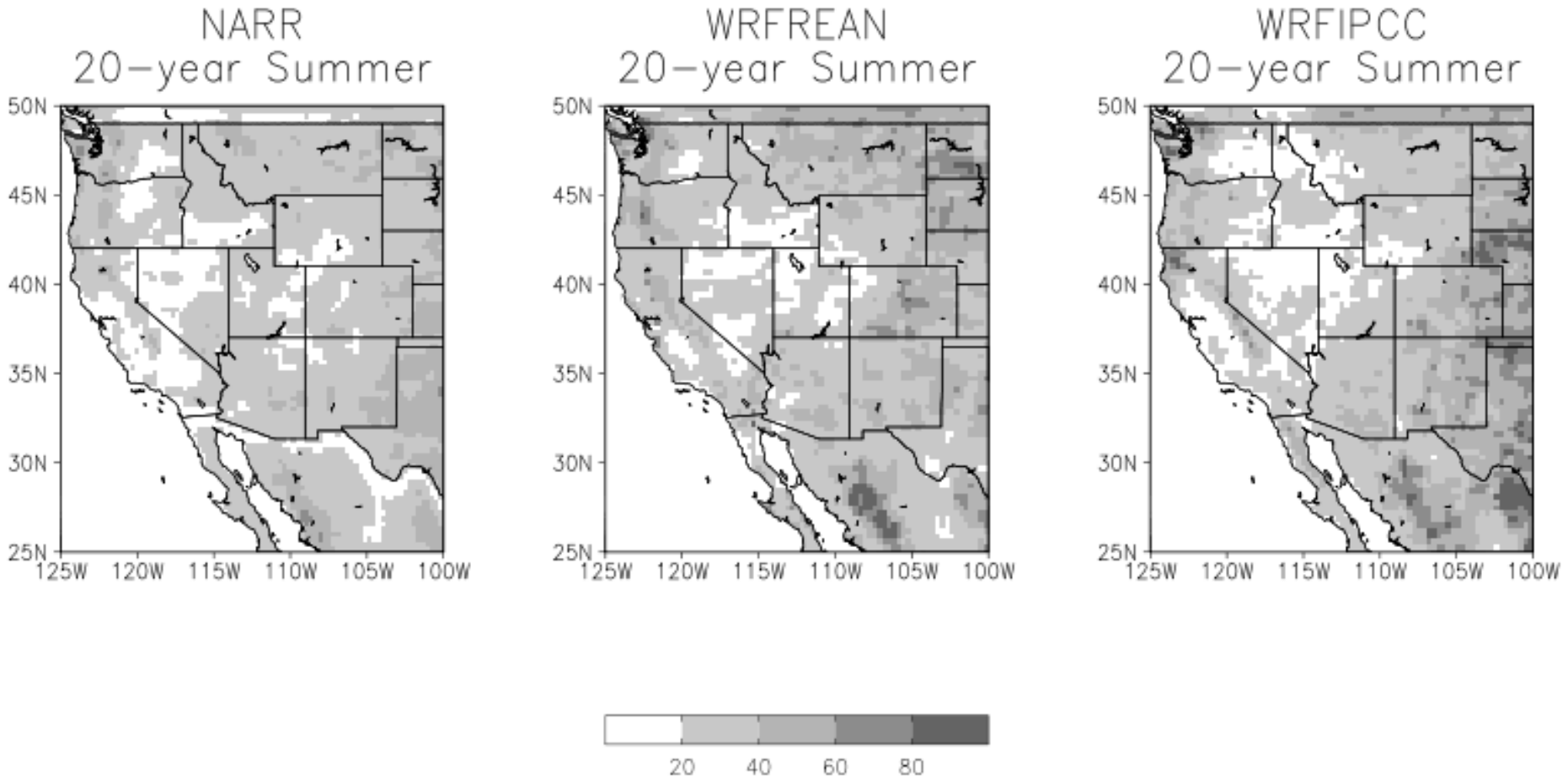


Change in WRF-HadCM3 dynamically downscaled precipitation in Arizona

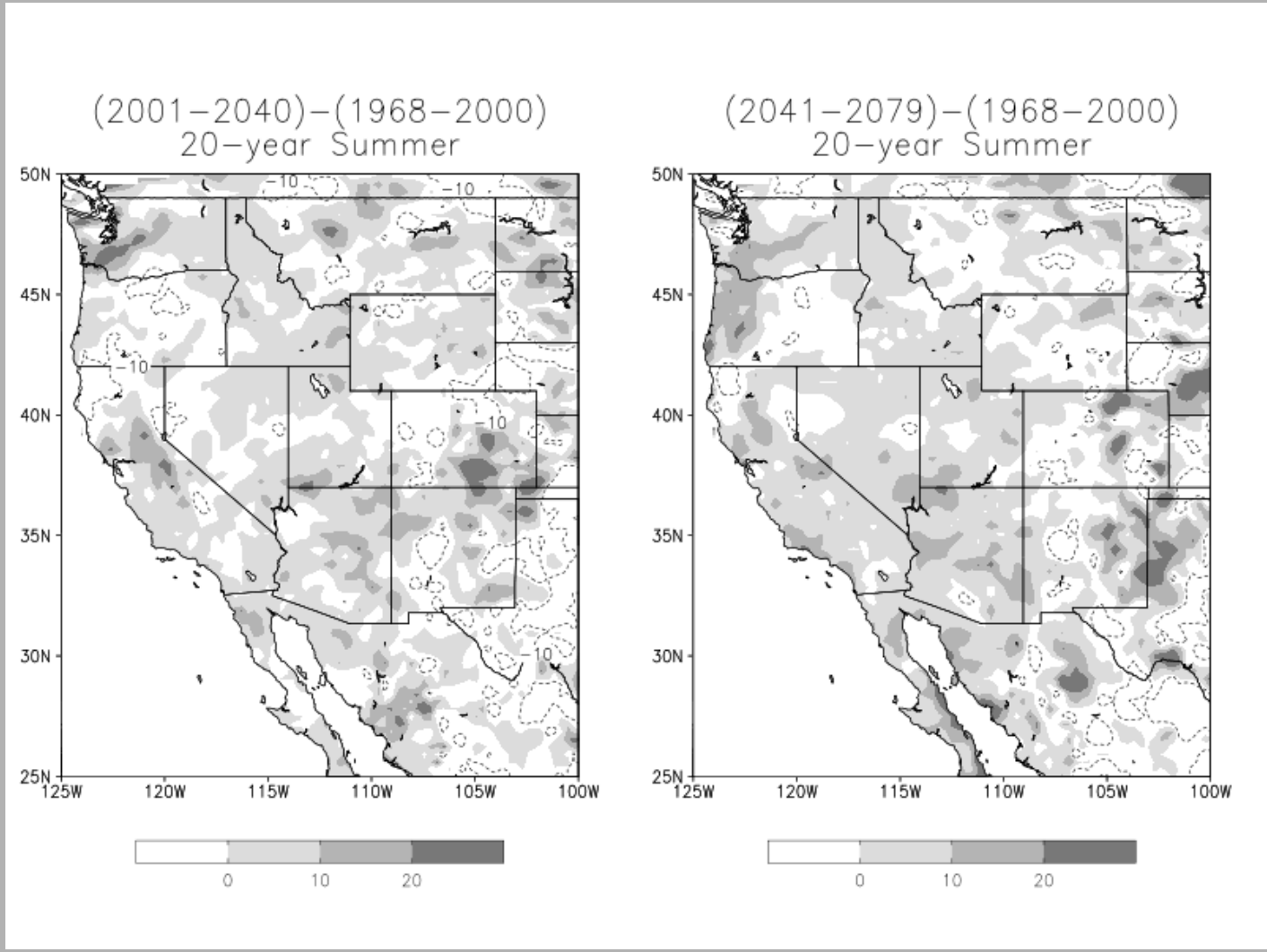


Maximum daily precipitation (mm) associated with 20 year return period

Characterized by a Poisson-GP Model

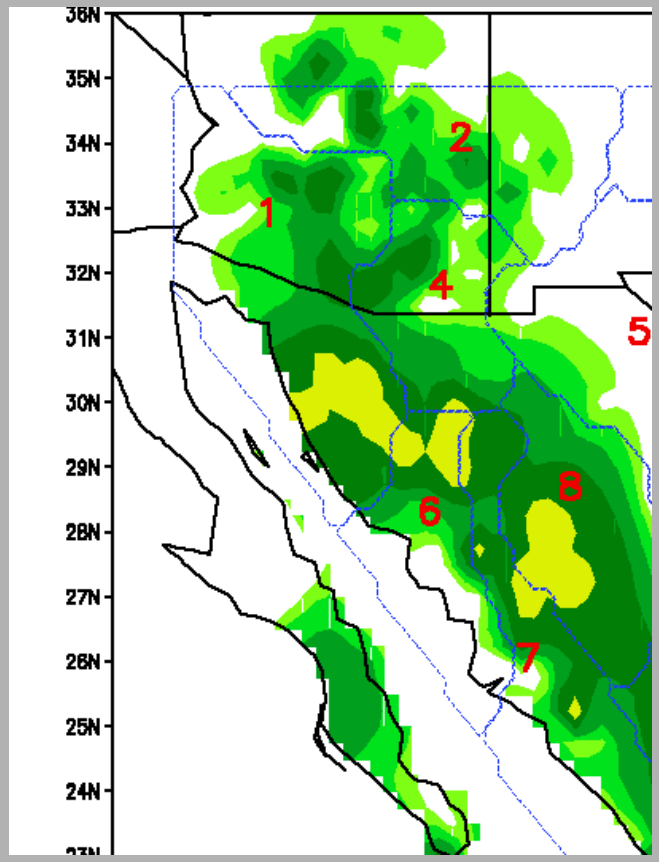


Change in maximum daily precipitation associated with 20-year return period

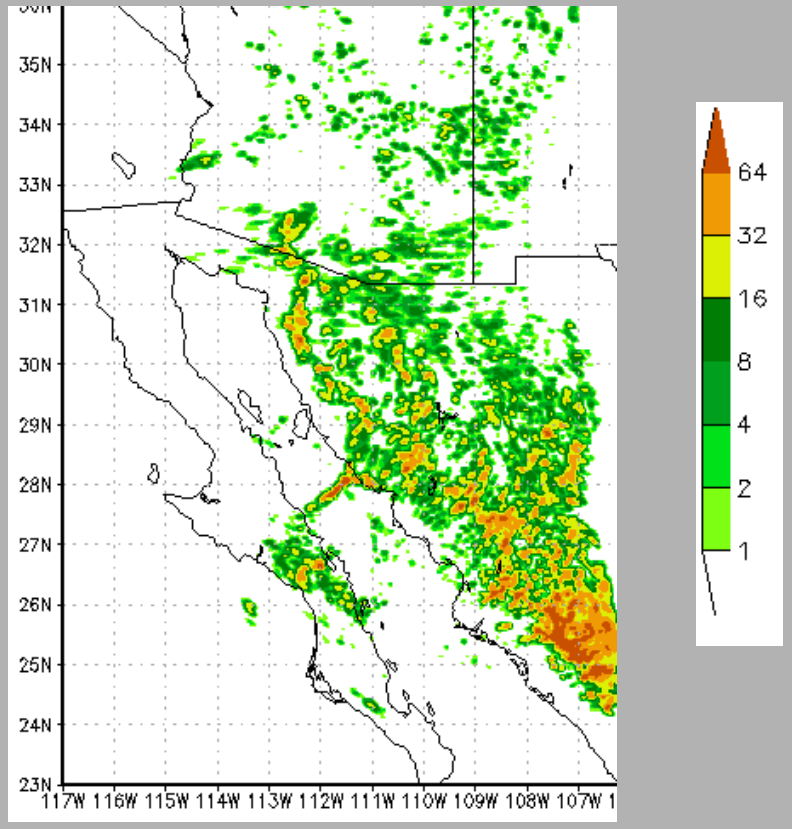


Simulation of selected extreme events at high resolution in NWP mode. NAME field campaign, IOP 2 (July 2004)

Observed Precipitation



WRF Simulated Precipitation



Conclusions

UNSUITABILITY OF GCMs FOR WARM SEASON:
Cannot resolve warm season, monsoonal climates well—a major caveat in the IPCC AR4 projections of drying in subtropical regions

RCMs CAN ADD SUBSTANTIAL VALUE: Can resolve resolve the mesoscale processes that lead to rainfall. May make NAMS seasonal forecasting feasible, and this work leads the way for next phase of MRED

Conclusions

NATURAL VARIABILITY MUST BE CONSIDERED : Modes of variability (e.g. ENSO, PDO) are critical, as that is what is responsible for generation of climate extremes. A multimodel average ensemble approach may not be most advantageous.

EXTREME EVENTS MATTER: Extreme precipitation events will increase in the future and this is already happening. High resolution NWP type modeling of extreme events can provide information at the spatial scale necessary for climate change decision making and adaptation.