Bias-Correction of Global Climate Model Output to Improve Regional Climate Modeling of the North American Monsoon

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Purpose

What we know:

- **Water resources in the SW U.S. are already stretched thin.**
- **Population in the region is expected to roughly double by 2050**
  - **Higher demand**

What changes are we already seeing in water resources?

- **Decreasing trend in winter snowpack in crucial headwater regions**
  - **Lower supply**
- **No major precipitation trend in the core region of the NAM (AZ, NM, Mexico), but positive trend along the northern edge of the NAM (CO, UT)**

Purpose:
Water is the Word

Low water levels could lead to restrictions

Posted on: 6:36 pm, April 8, 2013, by Nineveh Dinha

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Why care about water?

Lake Mead Could Be Within a Few Years of Going Dry, Study Finds

By FELICITY BARRINGER
Published: February 13, 2008

Lake Mead, the vast reservoir for the Colorado River water that sustains the fast-growing cities of Phoenix and Las Vegas, could lose water faster than previously thought and run dry within 13 years, according to a new study by scientists at the Scripps Institution of Oceanography.

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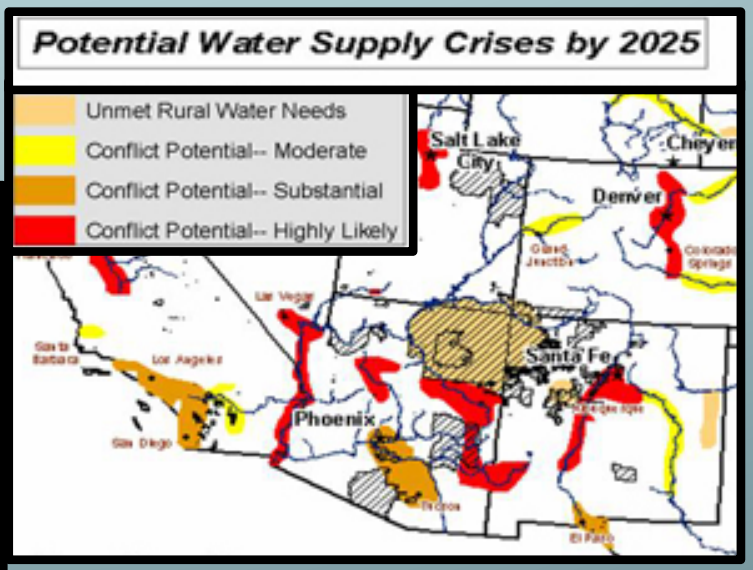


The North American Monsoon

- **Seasonal shift in the large-scale circulation patterns cause a dramatic change in moisture flow over the Southwest United States and most of Mexico.**

The North American Monsoon

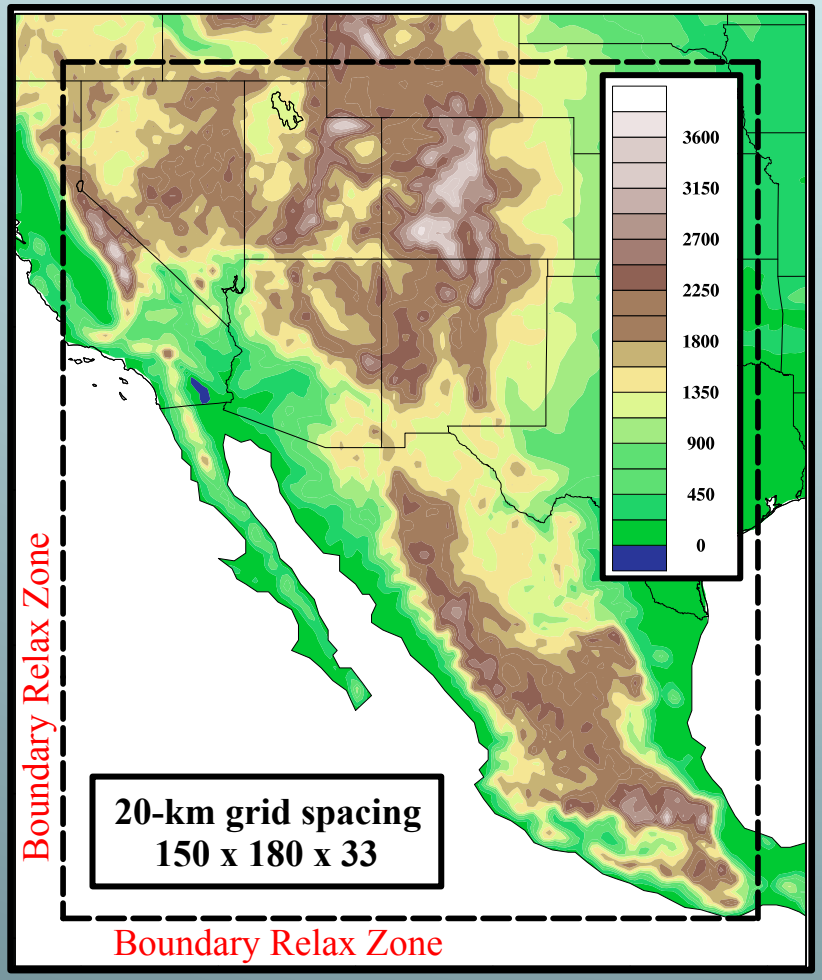
The majority of annual moisture for the Sierra Madre Occidental in Mexico

Upwards of 50% of the annual precipitation in southern Arizona and New Mexico.

Project setup

- **Three phases**
  - **I: Historical Calibration (1979-1999)**
    Calibrate the model physics and obtain understanding of strengths and weaknesses of how the model resolves the NAM
  - **II: Historical Prediction (2000-2009)**
    Using data independent from the bias-correction; but we still have observations to compare against.
  - **III: Future Prediction (2056-2065; 2090-2099)**
    Establish trends and assess impact of global warming

WRF Design



Project using WRF version 3.5, coupled with the Community Land Model (CLM) version 4.0.

Microphysics = Lin
Longwave Rad. = rrtm
Shortwave Rad. = Dudhia
Surface Layer = Monin-Ob.
Surface Physics = CLM4.0
PBL = MYNN2.5
Cumulus = BMJ

SST_update = True
Relax_Zone = 10

Data Sources

1. **NCEP-R1**
   - **Historical reanalysis (1949 -)**
   - **(2.5°x2.5°)**
   - **Calibrate model physics**

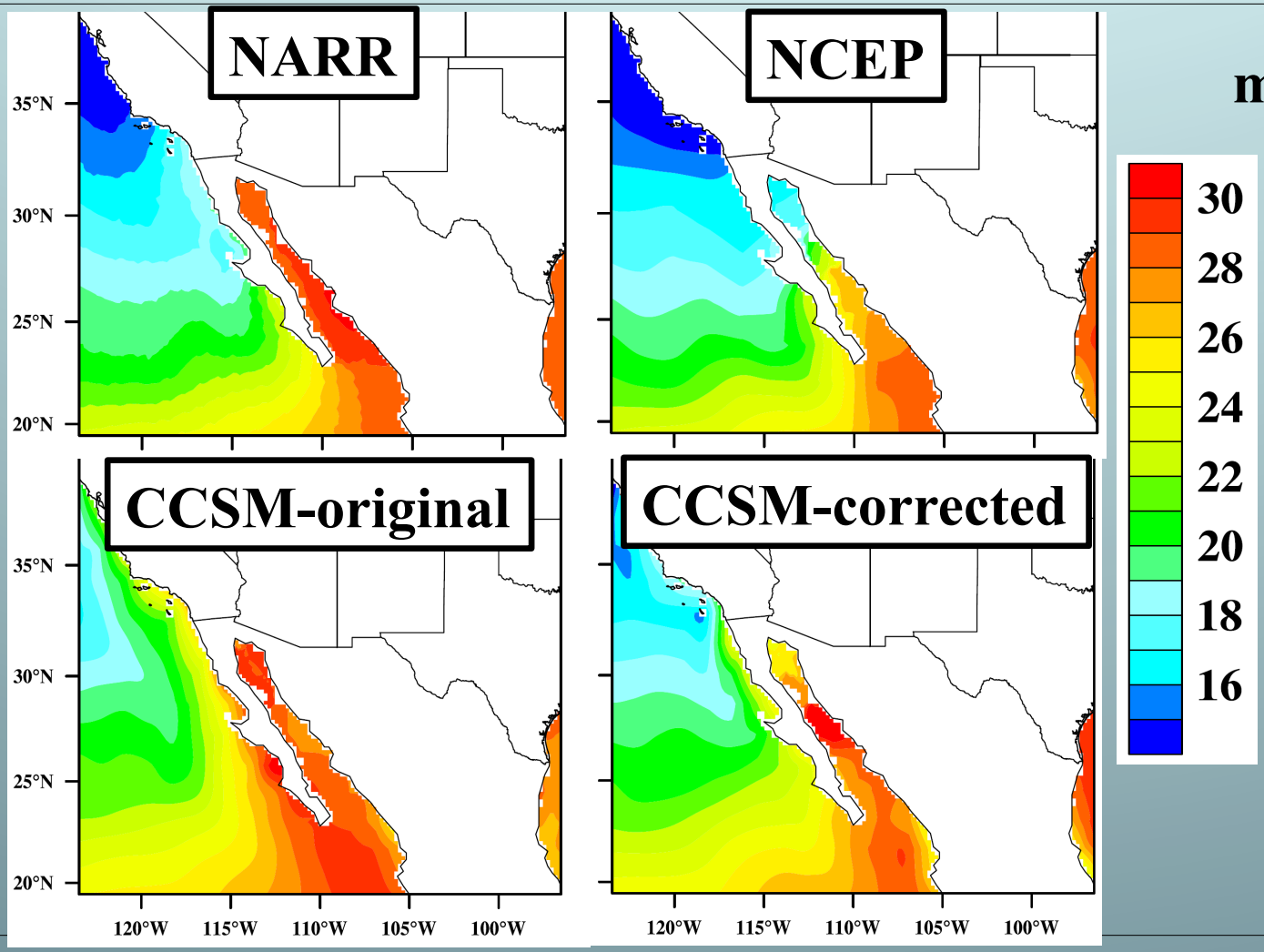
2. **Global Climate Model (GCM) ---------- CCSMv3**
   [A2 scenario]
   - **Historical hindcast + future prediction**
   - **(1.4°x1.4°)**

***** North American Regional Reanalysis (NARR)**
- **32-km**

Landmask comparison

Why do we need NARR?

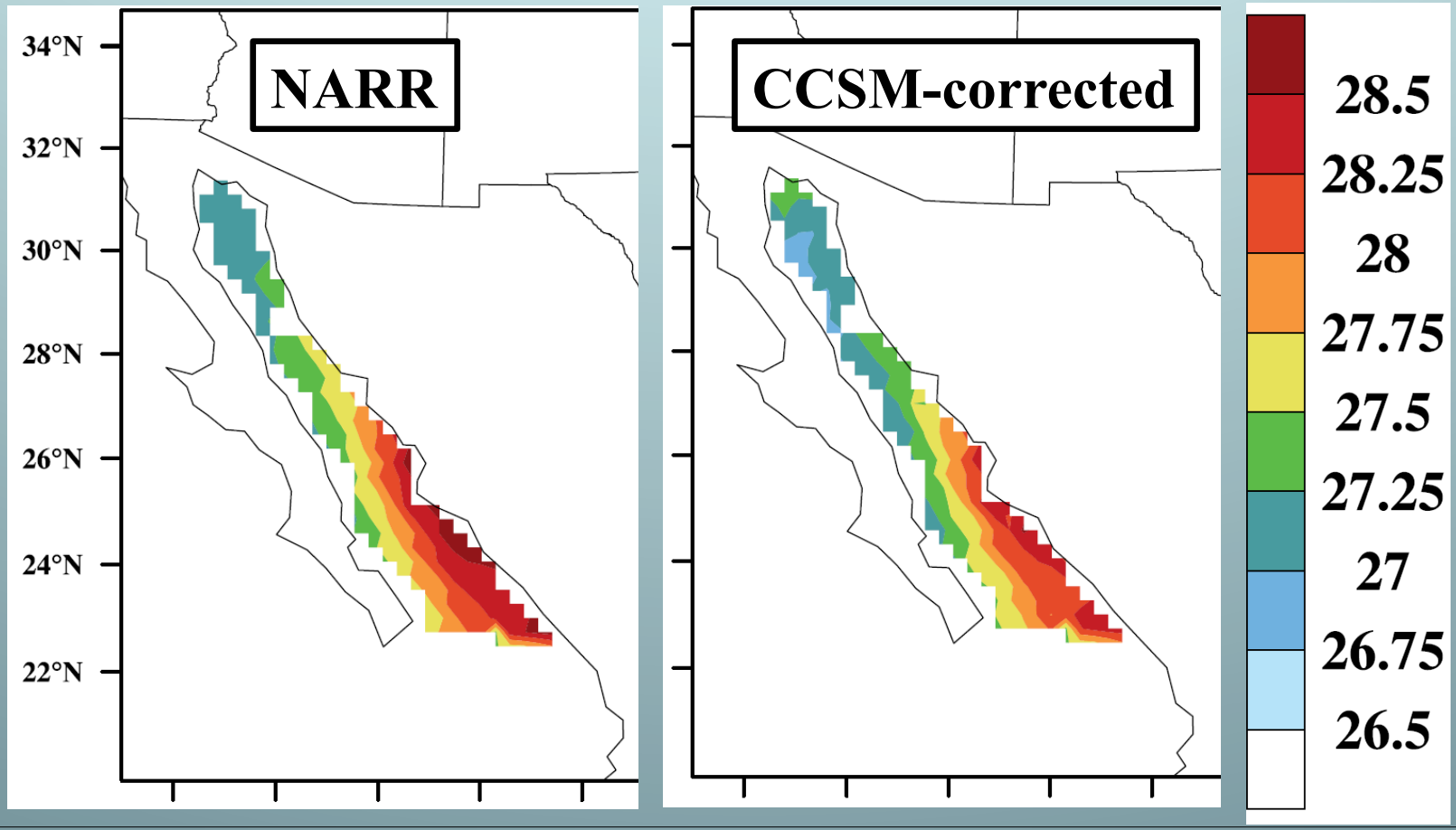
SST Comparison



met_em JJA SST

SST COMPARISON

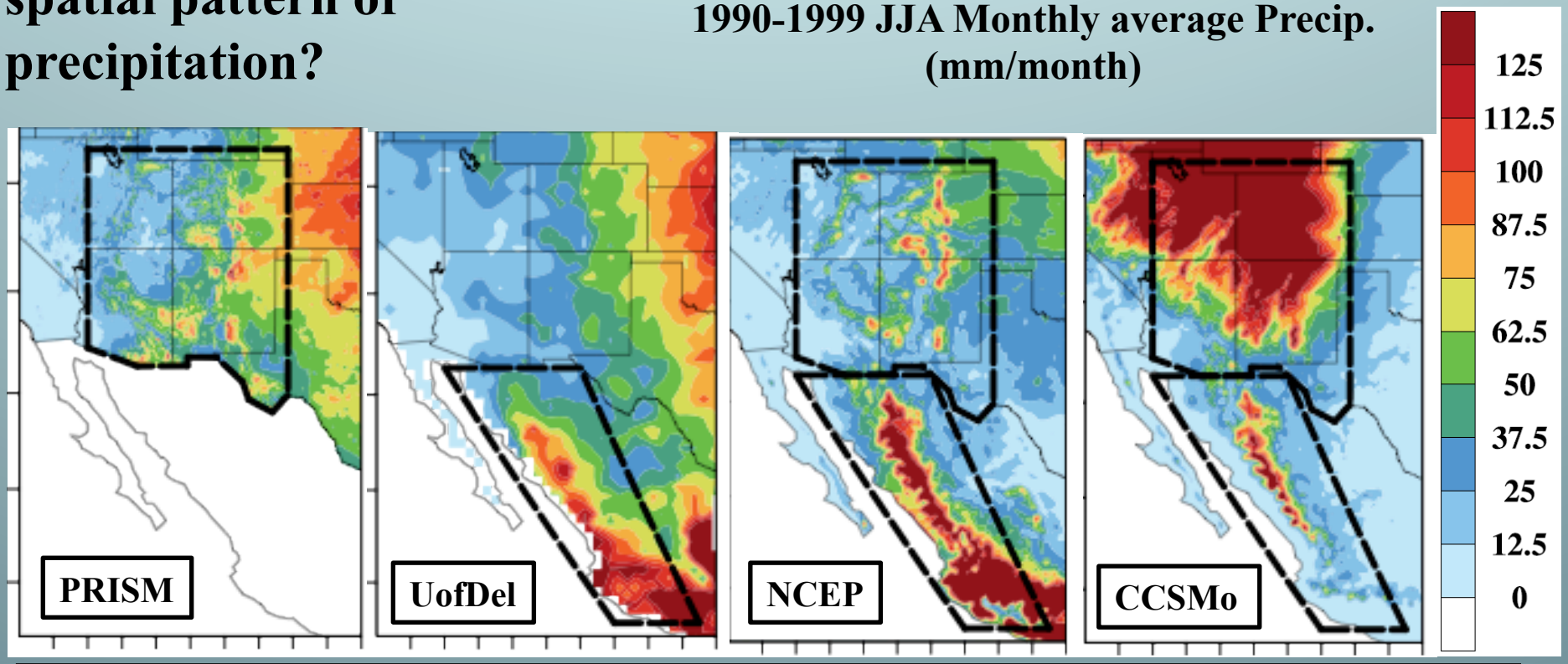
After using NARR SST to regress CCSM SST



Precipitation comparison

How well does the model capture the spatial pattern of precipitation?

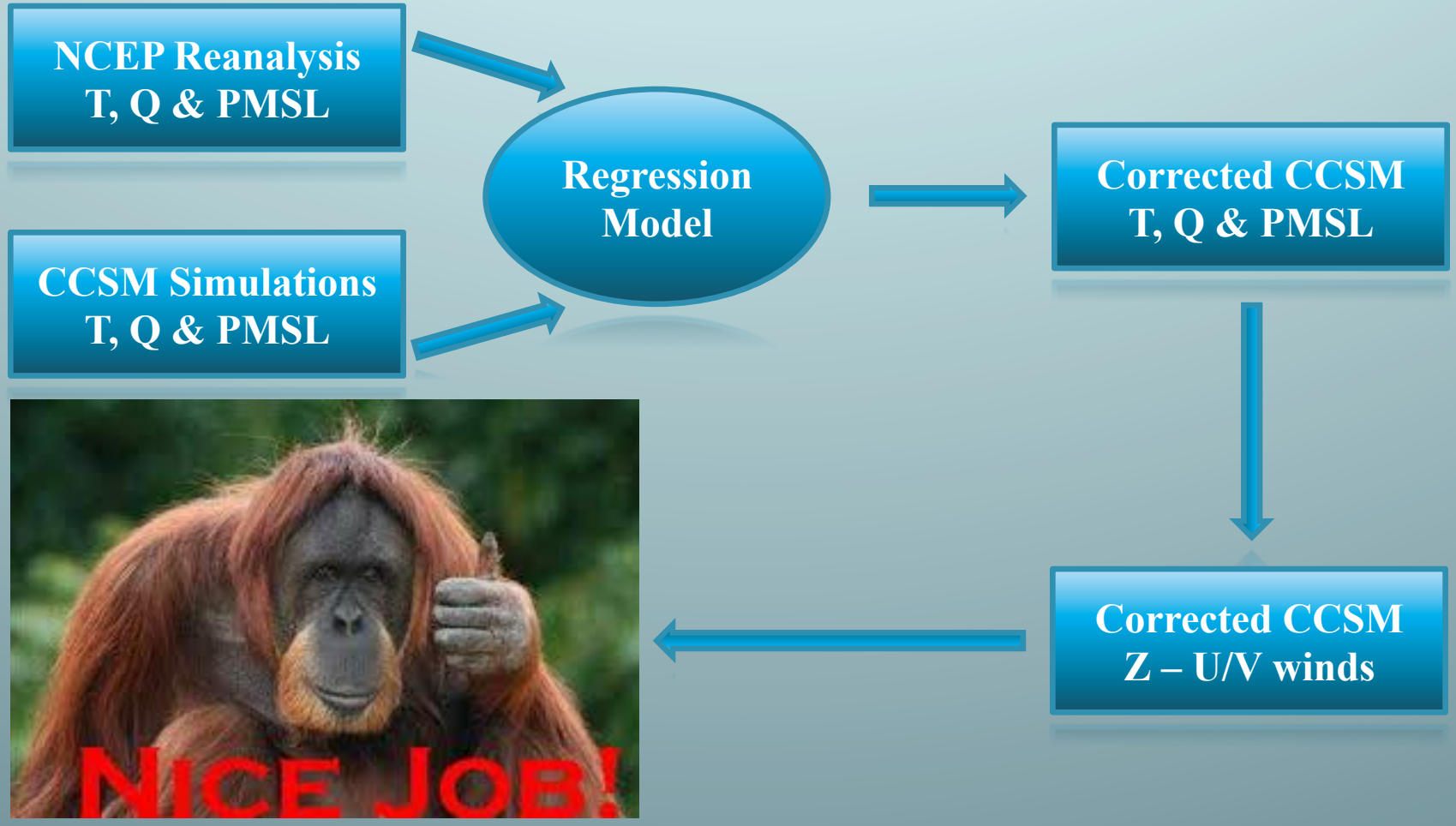
1990-1999 JJA Monthly average Precip. (mm/month)



Bias Correction

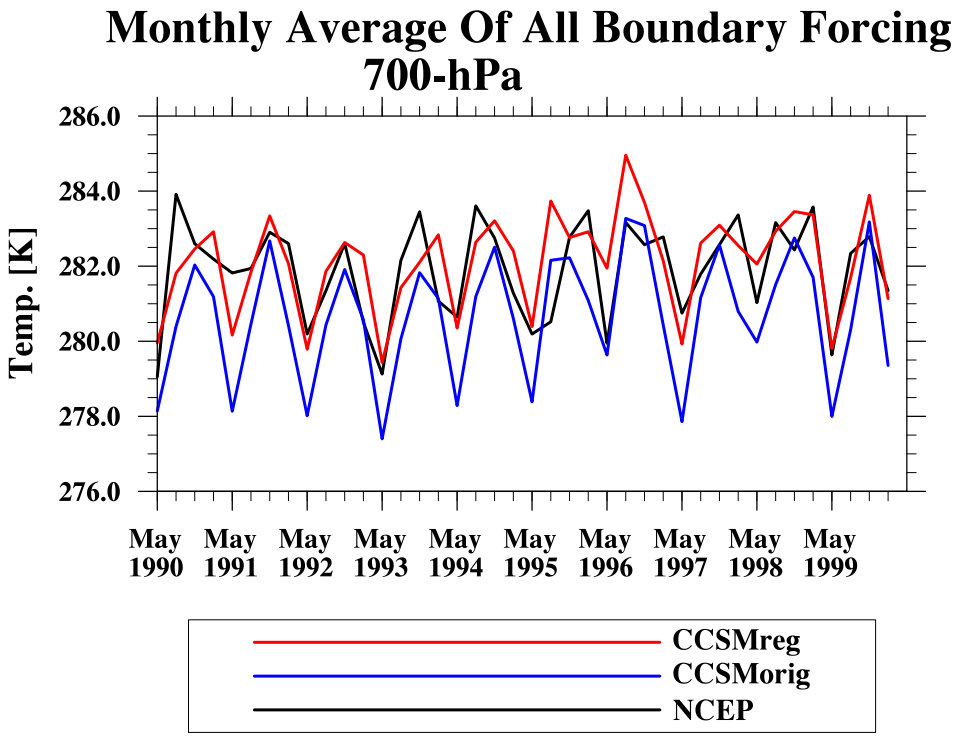
- **GCM Data Correction**
  - **Previous/Current types of bias correction of GCM data have corrected each variable independently.**
  - **Potential for a set of variables that are not physically possible in the real world.**
    - **Winds that don't match with height fields, that don't match with temperature fields.**
  - **Using NCEP data, we use a simple linear regression model to remove the mean climatological bias.**
    - **We have developed steps to conduct bias correction, while improving on the physical consistency between variables.**

Bias Correction



Boundary Condition Comparison

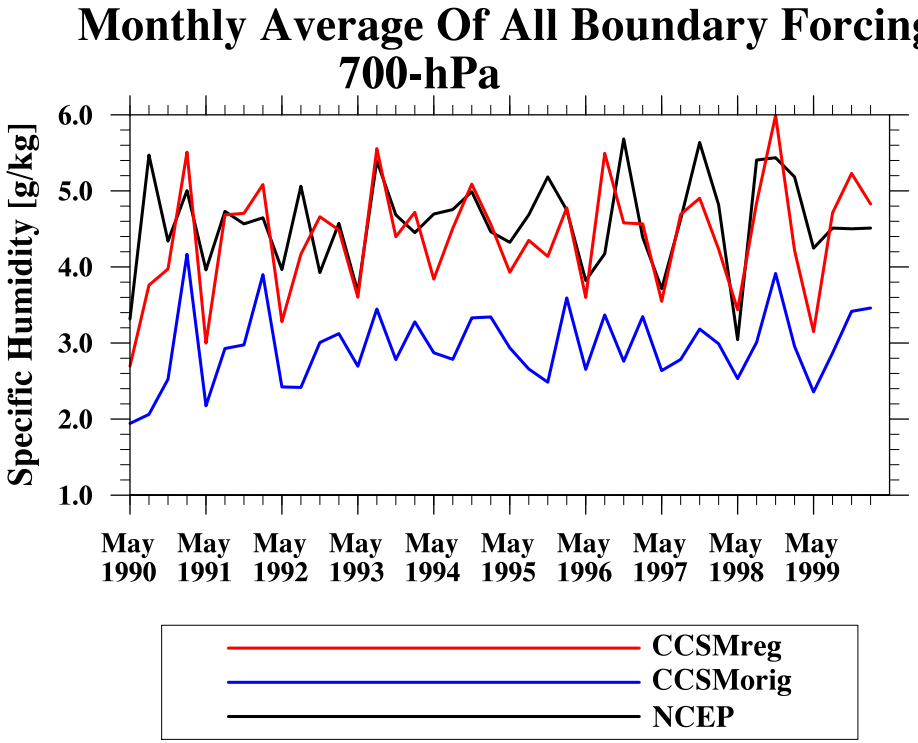
How much better is the corrected CCSM temperature data?



	Avg. Bias		Correlation		RMSD	
	CCSM orig	CCSM reg	CCSM orig	CCSM reg	CCSM orig	CCSM reg
700-hPa	-1.23	0.22	0.71	0.67	1.7	1.1
500-hPa	-1.56	0.03	0.66	0.65	1.9	1.1
250-hPa	-2.23	0.24	0.61	0.61	2.6	1.3

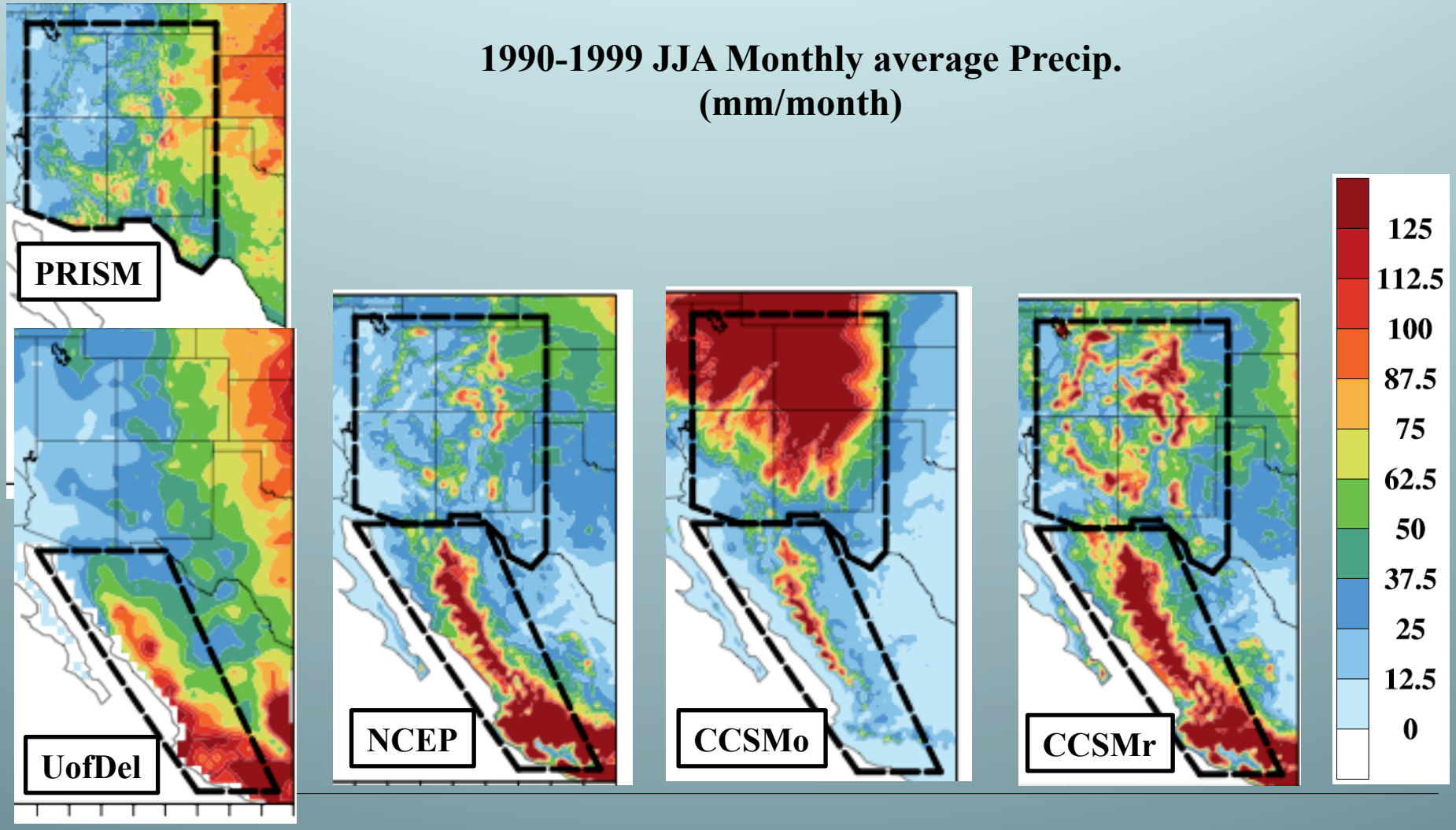
Boundary Condition Comparison

How much better is the corrected CCSM moisture data?



	Avg. Bias		Correlation		RMSD	
	CCSM orig	CCSM reg	CCSM orig	CCSM reg	CCSM orig	CCSM reg
850-hPa	-2.64	0.15	0.21	0.4	2.7	0.7
700-hPa	-1.63	-0.2	0.34	0.59	1.7	0.6
500-hPa	-0.03	0.01	0.44	0.61	0.4	0.3

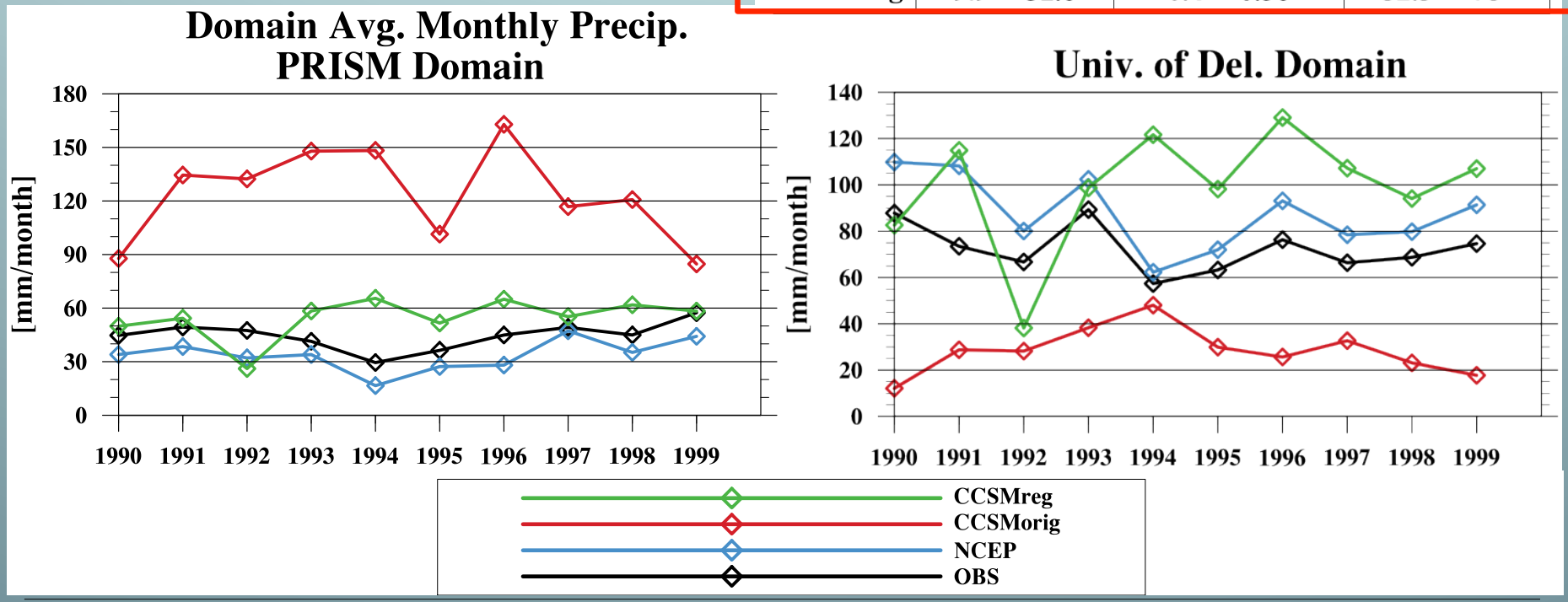
Corrected CCSM Precipitation Comparison



Corrected CCSM Precipitation Comparison

How well does the model capture the inter-annual variability of precipitation?

	Avg. Bias		Spatial Correlation		RMSD	
	sw U.S. PRISM	Mexico UofDel	sw U.S. PRISM	Mexico UofDel	sw U.S. PRISM	Mexico UofDel
NCEP	-11	19.5	0.68	0.65	19.1	76.2
CCSMorig	79.1	-41	-0.06	-0.02	132.1	64.8
CCSMreg	9.9	31.6	0.4	0.56	32.3	78



Summary

- **When using reanalysis data, calibrated model results show WRF model physics/dynamics are able to appropriately reproduce NAM precipitation patterns and inter-annual variability for our purpose.**
  - **Captures convective initiation over topography, but struggles to maintain convection through evening/night.**

- **Large improvements to precipitation occur through bias correction of CCSM forcing data.**
  - **Wet bias in SW U.S., but spatial pattern looks much better.**

Thank You

Questions???

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