What is necessary to improve seasonal forecasts and climate change projections of the North American Monsoon?

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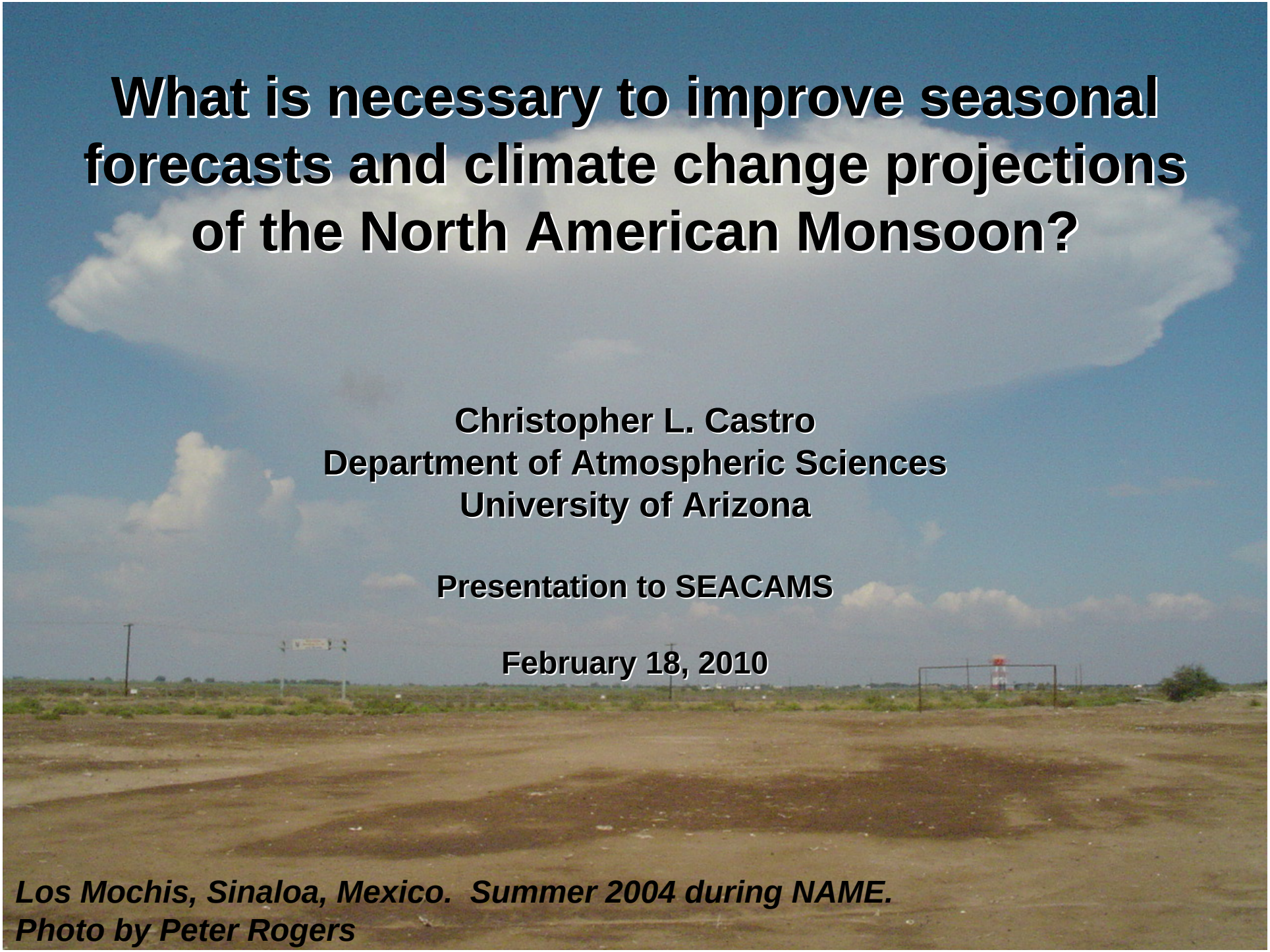
Presentation to SEACAMS

February 18, 2010



Los Mochis, Sinaloa, Mexico. Summer 2004 during NAME. Photo by Peter Rogers

Presentation Topics

What is the North American Monsoon and why is it important for Mexico and the United States?

Can we trust current global models to represent the monsoon?

Important factors that influence monsoon variability on climate timescales

What is needed to improve monsoon forecasts and projections?

Concluding points

Acknowlegements: ***Drs. Dave Gochis, Jae Kyung-Schemm, Tereza Cavazos and other members of the NAME Science Working Group. Also to Dr. Francina Dominguez and Brittany Ciancarelli from UA.***

What is the North American Monsoon (...in brief)

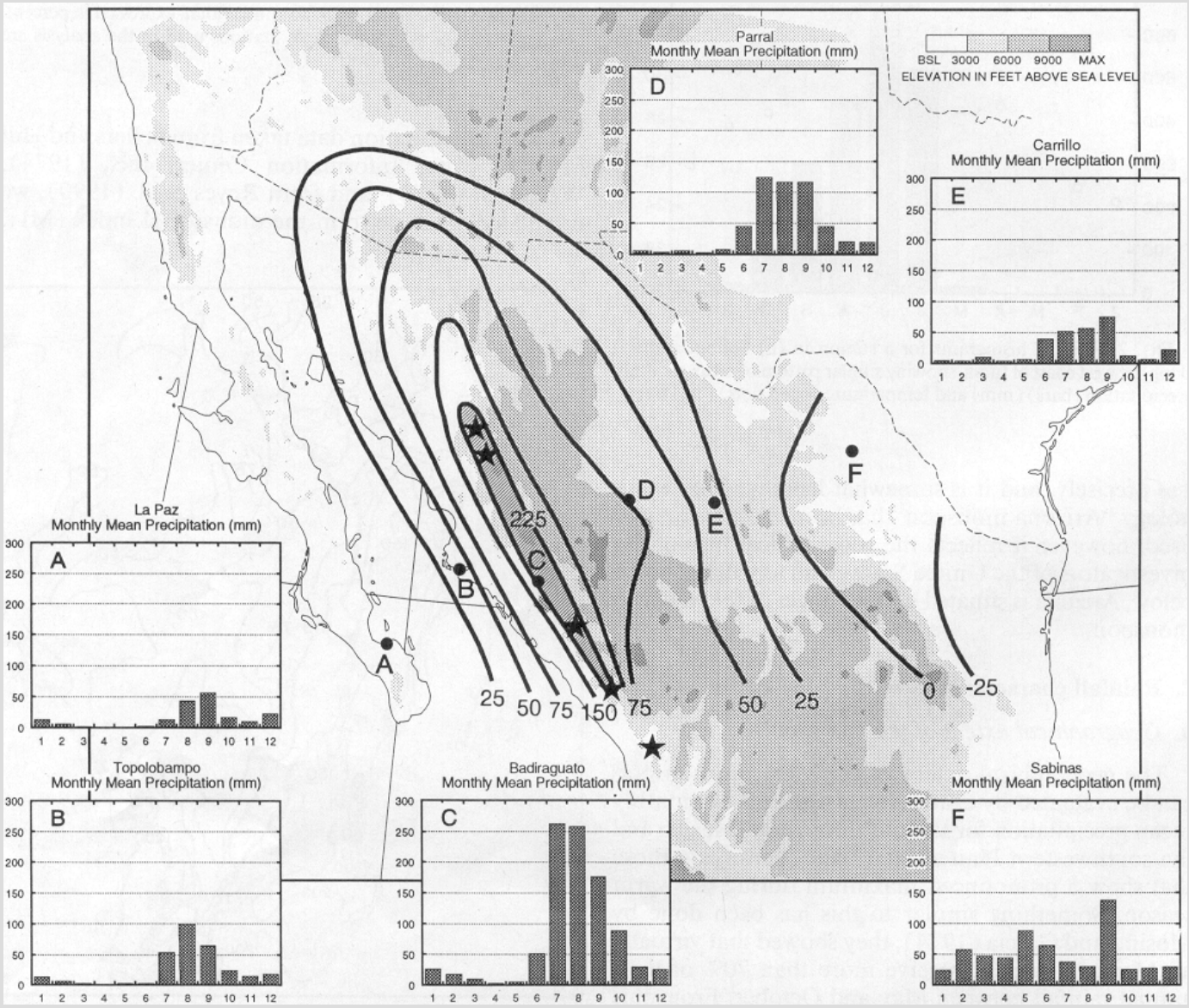
The period of maximum precipitation in northwest Mexico and parts of the southwest United States, including Arizona.

Rains begin usually at the end of June in Mexico and several weeks later in July in Arizona and New Mexico. They persist usually until the end of August or beginning of September.

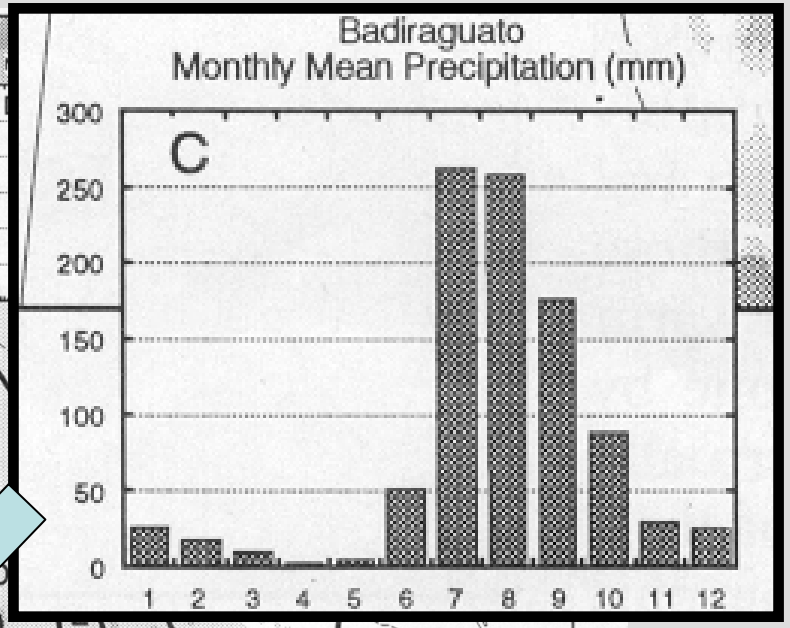
Monsoon rainfall is from localized thunderstorms and these can vary a lot in intensity and frequency during the summer.

The majority of rainfall is localized in the mountains because the formation of storms depends on the influence of the terrain.

Monthly average summer precipitation in northwest Mexico



The Sierra Madre Mountains during the monsoon

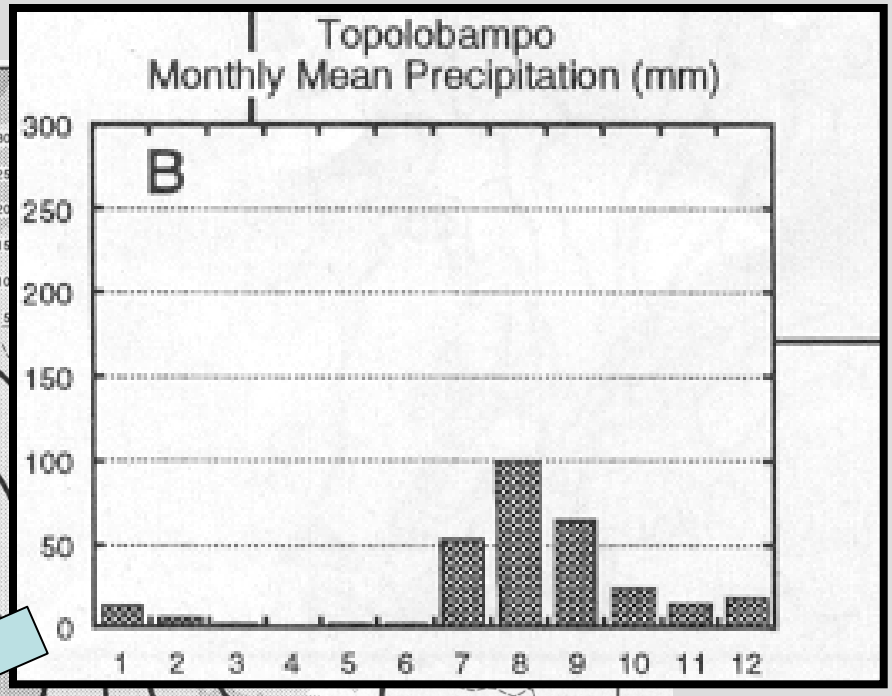


The majority of rain is localized in the mountains of the Sierra Madre

The monthly average precipitation is more than 200 mm in July and August.

Note the rapid increase in precipitation between June and July.

Near Topolobampo



Farther away from the mountains towards the coast of the Gulf of California, there is less precipitation

Also, the precipitation occurs only occasionally and not every day.

Importance of the monsoon
Example of the state of Sonora, Mexico

More than sixty percent of the water in the region comes during the summer. The state depends on summer rainfall for water and agricultural resources.

Can we trust current global models to represent the monsoon?

What interests us:

Seasonal forecasts (from NOAA)

Climate Change Projections (from IPCC)

Video
U.S. News
Crime & Punishment
U.S. Life
U.S. Security
Education
Environment
Race & Ethnicity
Charity News
Only on MSNBC.com
Peculiar Postings
Politics
World News
Business
Sports
Entertainment
Health
Tech / Science

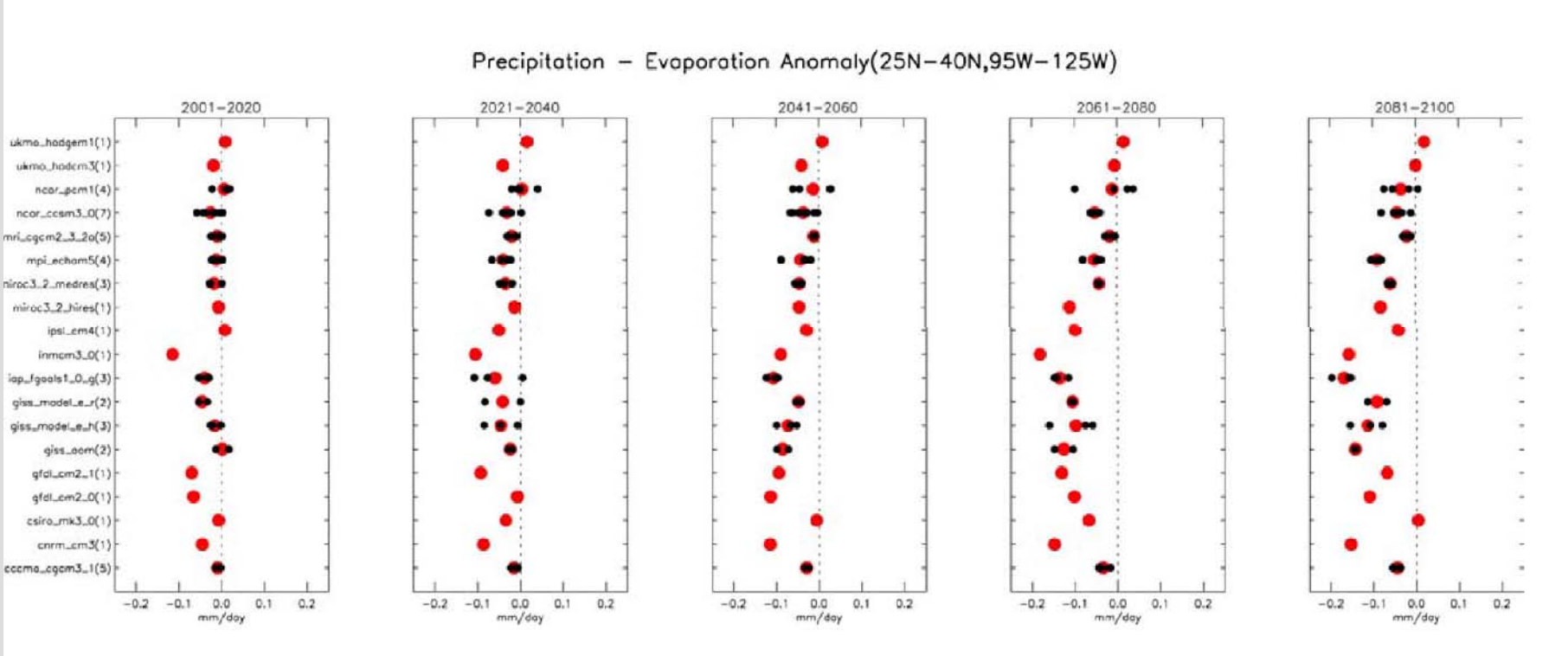
Scientists predict Southwest mega-drought

Climate models indicate region will be as dry as Dust Bowl for decades

David Mcnew / Getty Images

A bleached "bathtub ring," the result of a six-year drought that has dramatically dropped the level of the reservoir, shows on red Navajo sandstone formations near Last Chance Bay at Lake Powell near Page, Ariz. Lake Powell and the next biggest Colorado River reservoir, the nearly 100-year-old Lake Mead, are at the lowest levels ever recorded.

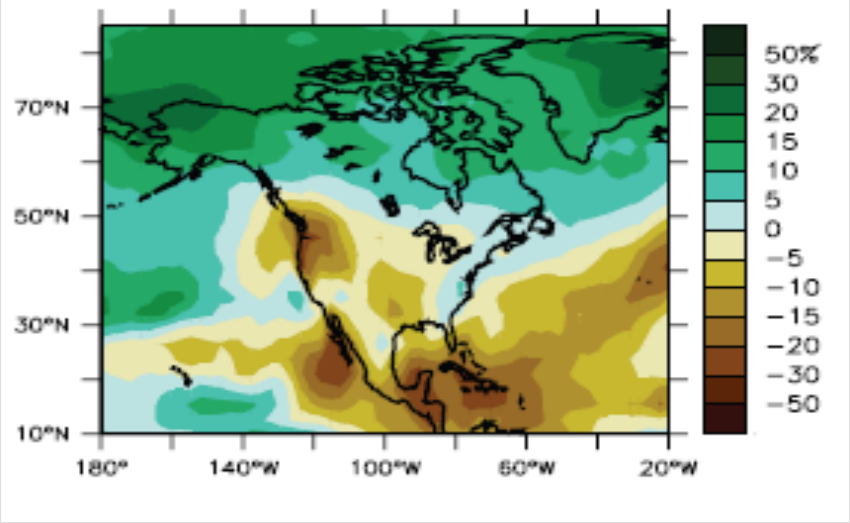
IPCC GCM P-E results for the Southwest United States (relative to model climatologies)



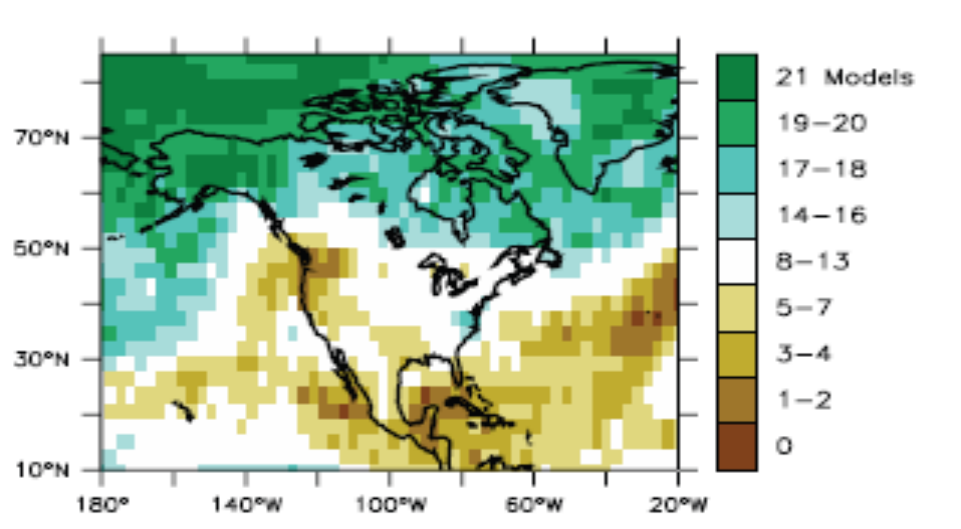
Seager et al. (2007)

My question: How can we trust these results when virtually all these models have little or no representation of summer rainfall?

Percentage change in summer precipitaiton at the end of this century by IPCC models (scenario A1B)



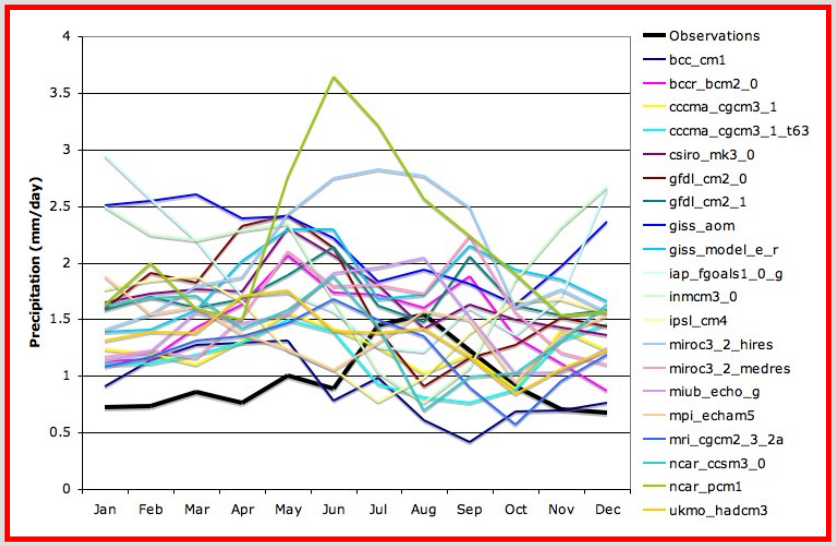
The level of agreement between these models

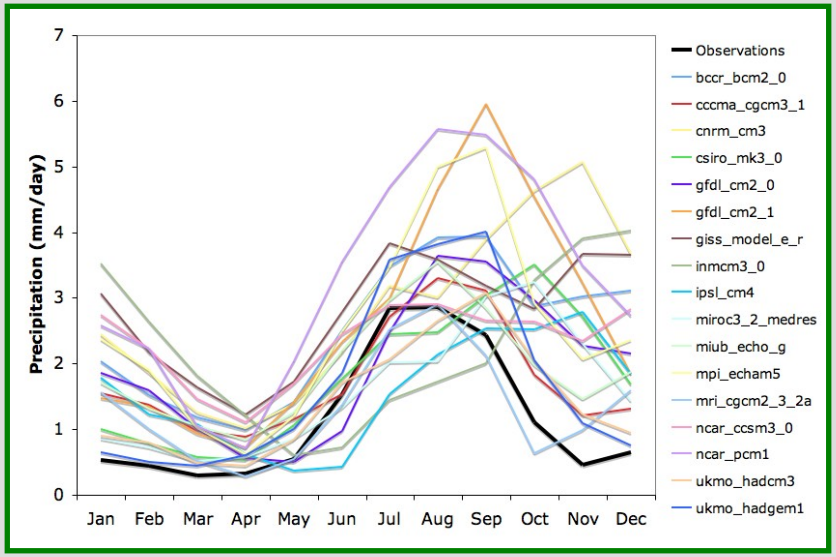


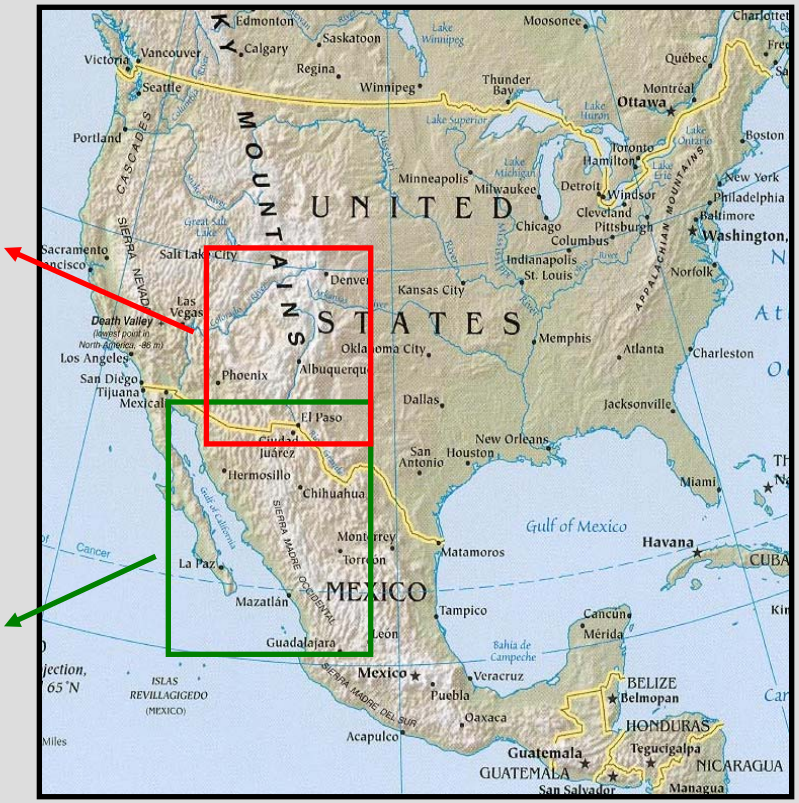
Current IPCC models indicate that summer precipitation will not change much.

But we cannot trust this projection much because of the disagreement among the models.

Monthly average precipitation from all IPCC models during the past century







Average of historical simulations (sres_20c3m) 1970-2000

(Francina Dominguez)

"On The Importance Of Regional Climate Change Projection In The Southwest U.S. — And Its Caveats by Professor Christopher L. Castro" - "Though I am not a regular contributor to Dr. Pielke's blog, I would like to comment on some recent discussions regarding climate change projections in the southwest United States. To give some brief background on myself, I am a former student of Dr. Pielke's and currently an assistant professor at the Department of Atmospheric Sciences at the University of Arizona. My principal interests are regional climate and mesoscale modeling." (Climate Science)

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"ALL THE JUNK THAT'S FIT TO DEBUNK"

Archives - June 2007

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"Meteorologist: 'Al Gore's Global Warming is the Biggest Myth of the Century'" - "I'm sure I'm speaking for millions of anthropogenic global warming skeptics when I say that virtually nothing brightens my day more than an article written by a climate expert exposing the Global Warmingist-in-Chief, soon-to-be-Dr. Al Gore, as nothing more than a snake oil selling charlatan." (Noel Sheppard, News Busters)

"Gore's assault on reason" - "The title of Al Gore's latest book, The Assault on Reason, says it all. Illogicalities, non sequiturs, false analogies, fallacies, ad hominem (or rather ad Exxoninem) arguments all tumble forth in profusion from its pages." (Peter Foster, Financial Post)

The way it could have been...

Buddies For Life

The way it is

AND THE IPCC MODELS <u>WITHOUT A DOUBT</u> TELL US THAT ALL OF THE SOUTHWEST U.S. WILL TURN INTO A GIANT, BURNING WASTELAND!!

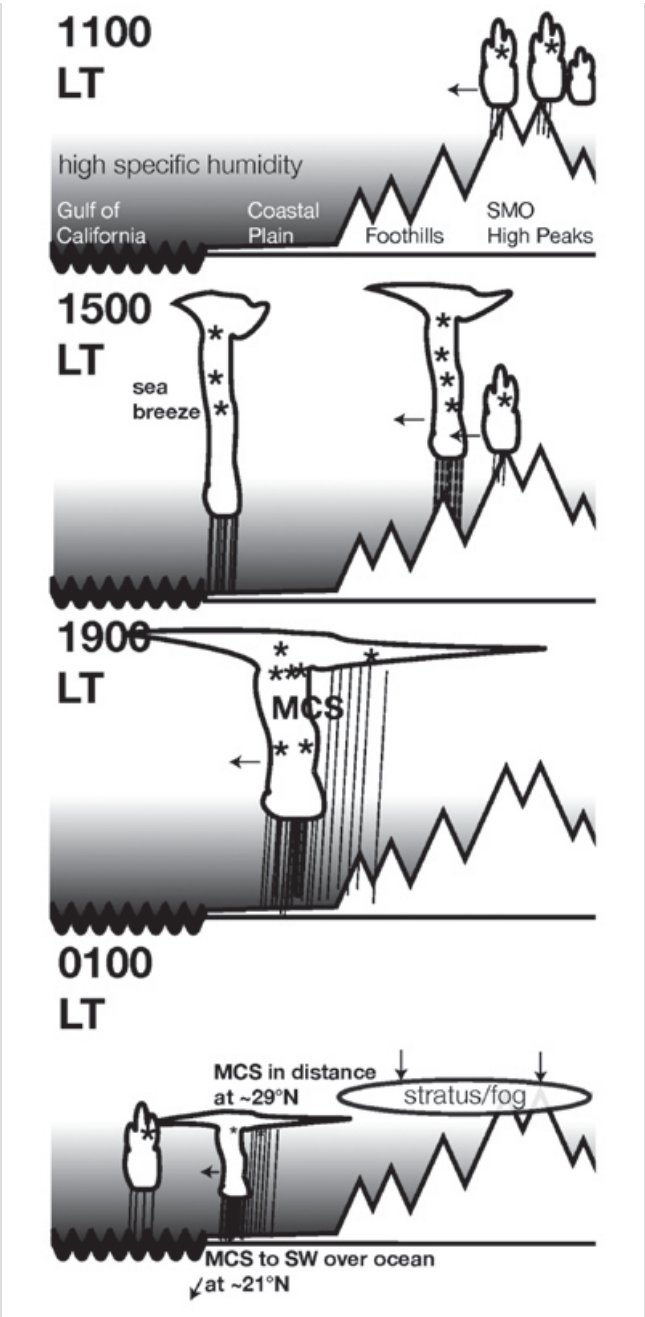
EXECUSE ME, AL…THOSE GCMs AIN'T EVEN GOT A MONSOON IN THEM!!

Nemeses

So just how's that snake oil, climate changey thingy working out for ya?!

To make a climate simulation of the North American Monsoon with an atmoshperic model that has value, it is necessary that the model represent the factors that influence it's variablity "good enough."

That isn't so easy!



(Nesbitt et al. 2008)

Diurnal Cycle of Convection

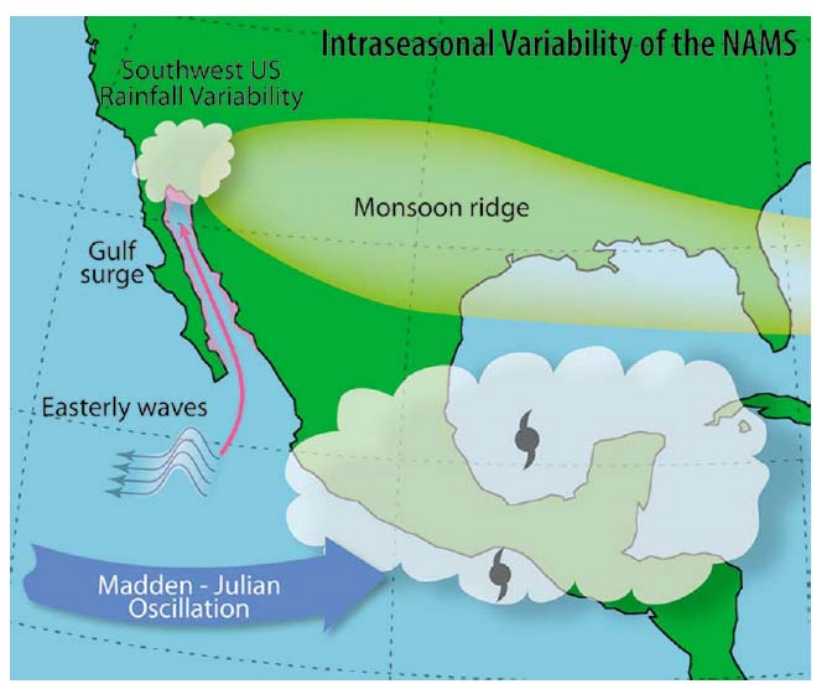
Most important

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.

It's likely that a resolution less than 5 km is necessary to represent this process correctly in regional models. Global models pretty much fail.

Intraseasonal variability



(Moloney et al. 2008)

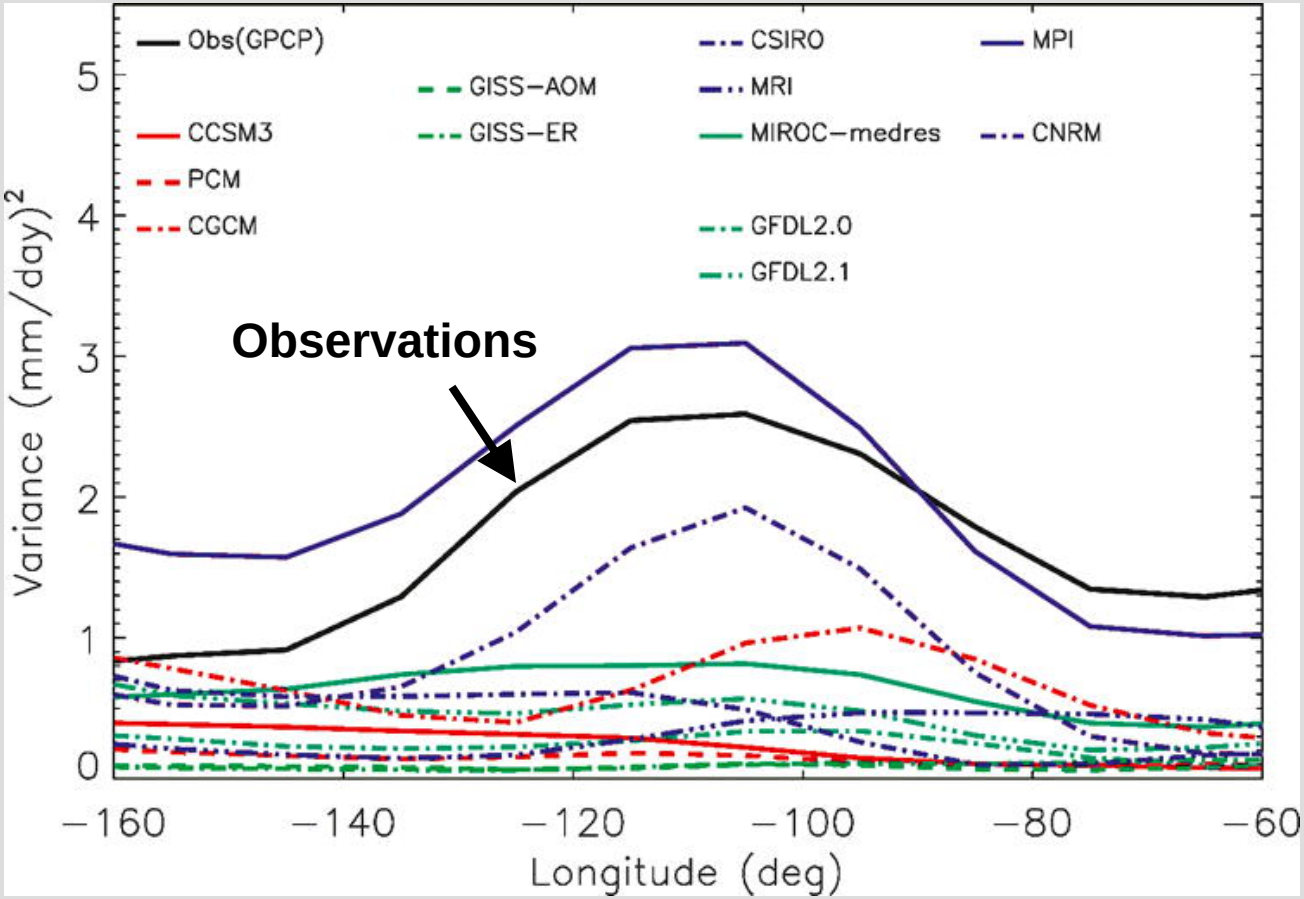
Includes:

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

All these factors can help convection organize and intensify.

Can IPCC models represent easterly waves?

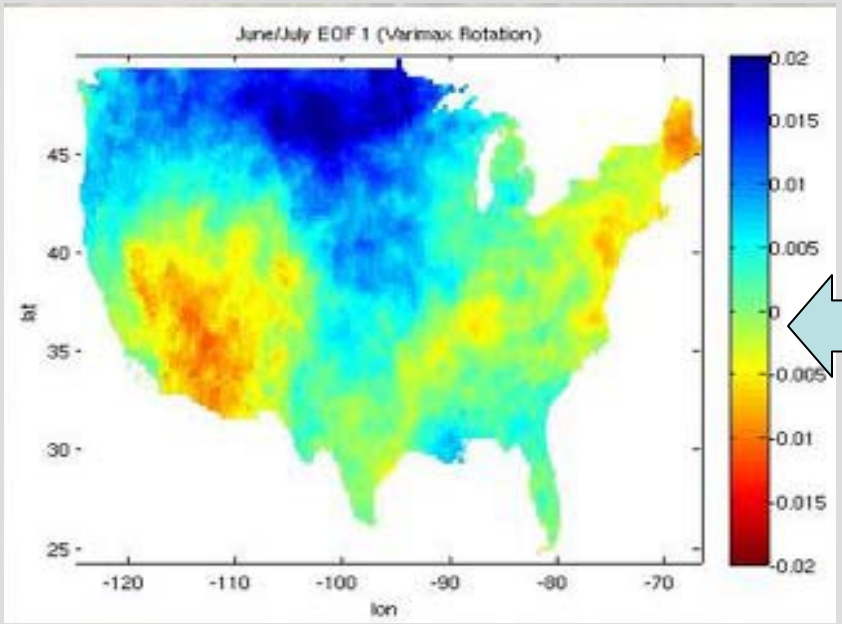
Their variability from 10 to 20º N during the warm season



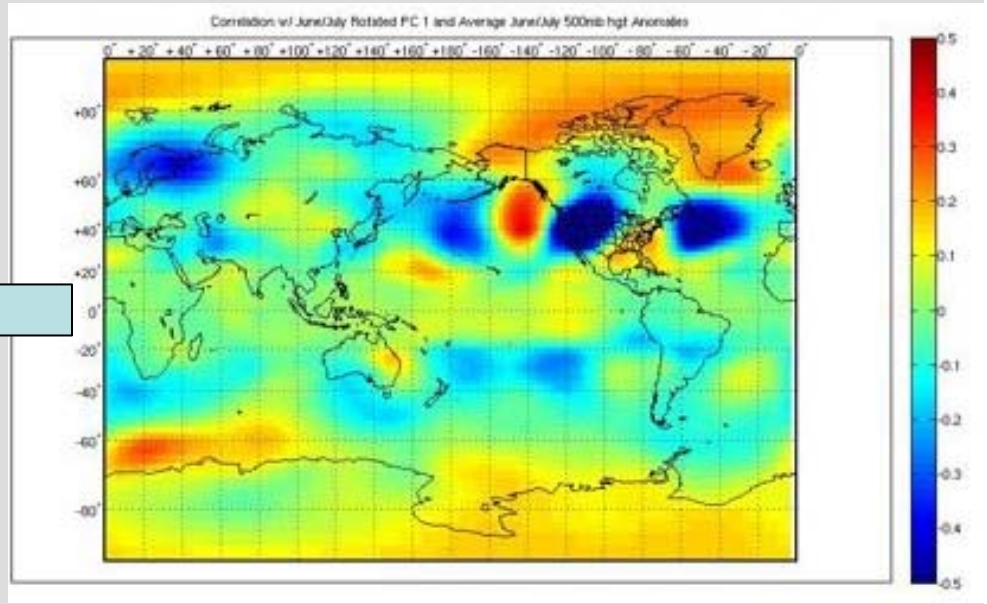
Lin et al. (2009)

Monsoon Interannual Variability

<u>Idea</u>: Atmospheric teleconnections that originate in the western Pacific (and maybe other places) affect the distribution and amount of rainfall, especially in the early part of the summer.



The dominant spatial pattern of precipitation anomalies (SPI) in early summer.

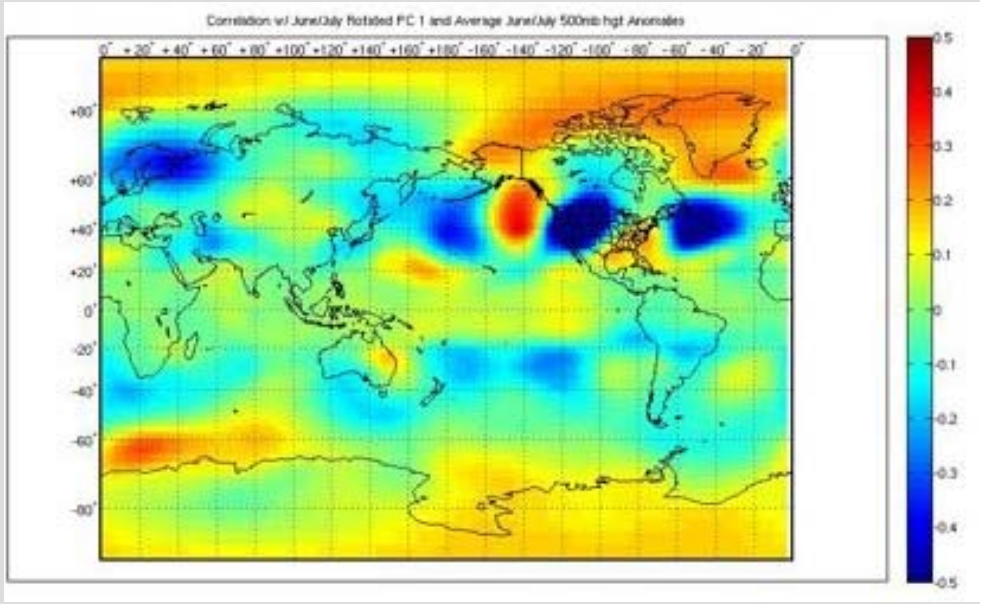


Its relationship to large-scale circulation (500-mb height anomalies).

Ciancarelli et al. (2009)

It is necessary that a model represent this summer teleconnection pattern.

If not, there is no hope of making a seasonal forecast that has value.



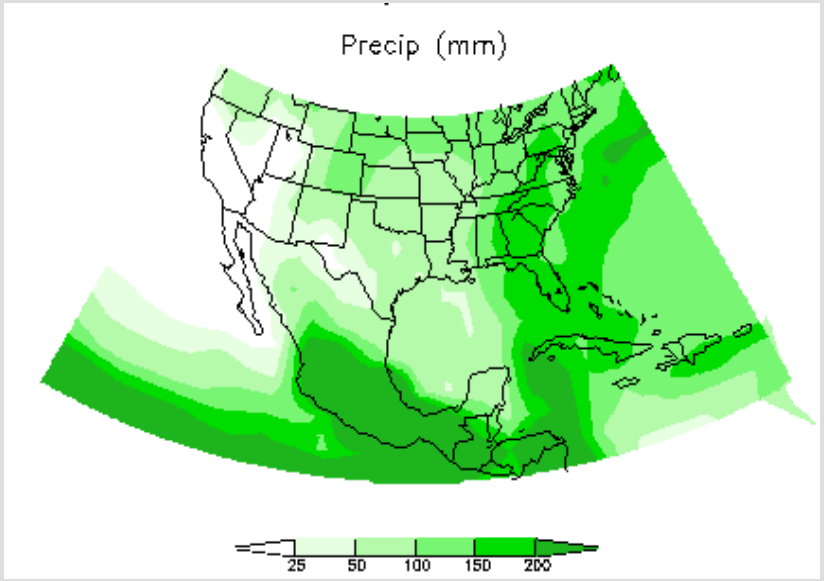
Relationship with atmospheric circulation (500-mb height anomalies).

Can we use high resolution atmospheric models to improve forecasts and projections?

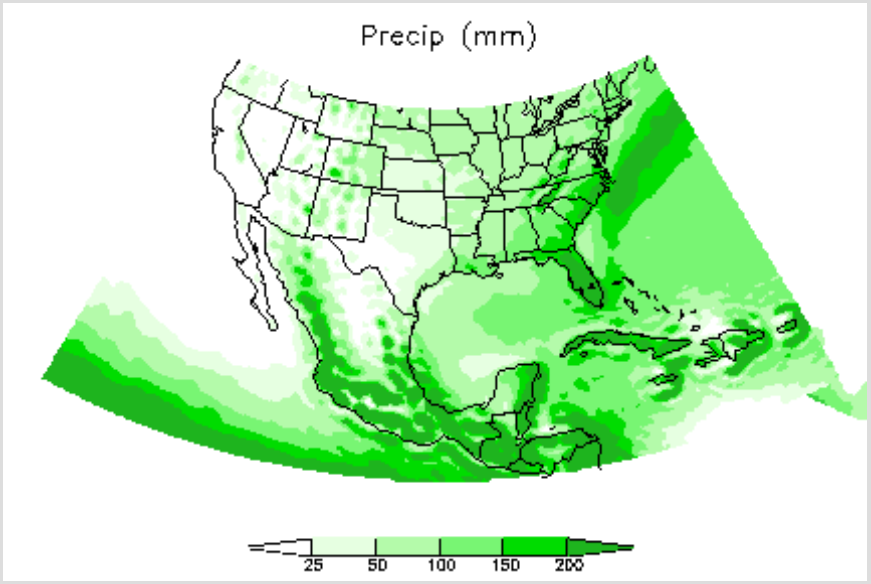
Some examples…

Seasonal forecasts of accumulated precipitation during summer 2009

National Center for Environmental Prediction (NCEP)



Current global model with low resolution (~200 km)

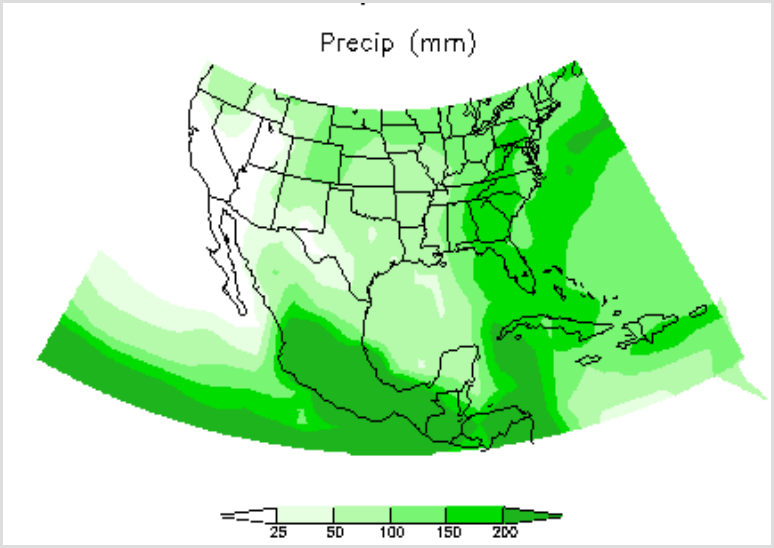


Experimental global model with high resolution (~35 km)

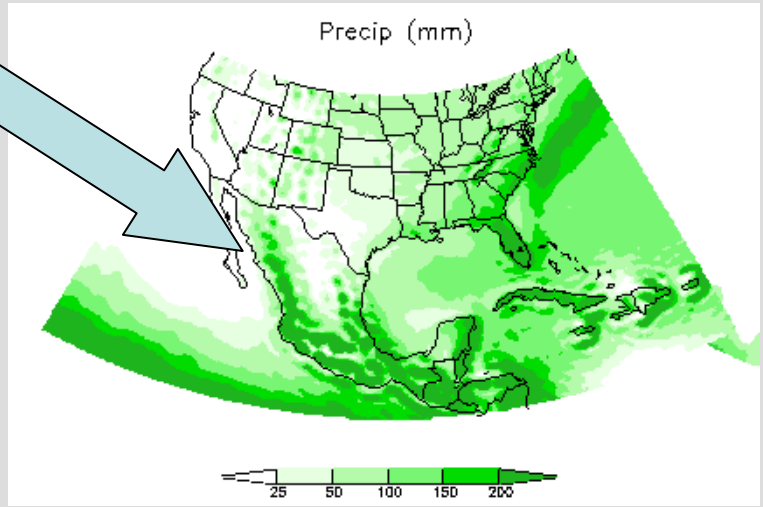
(Jae Schemm, NCEP)

Note the increase in precipitaiton in the mountains due to the better representation of the diurnal cycle of convection.

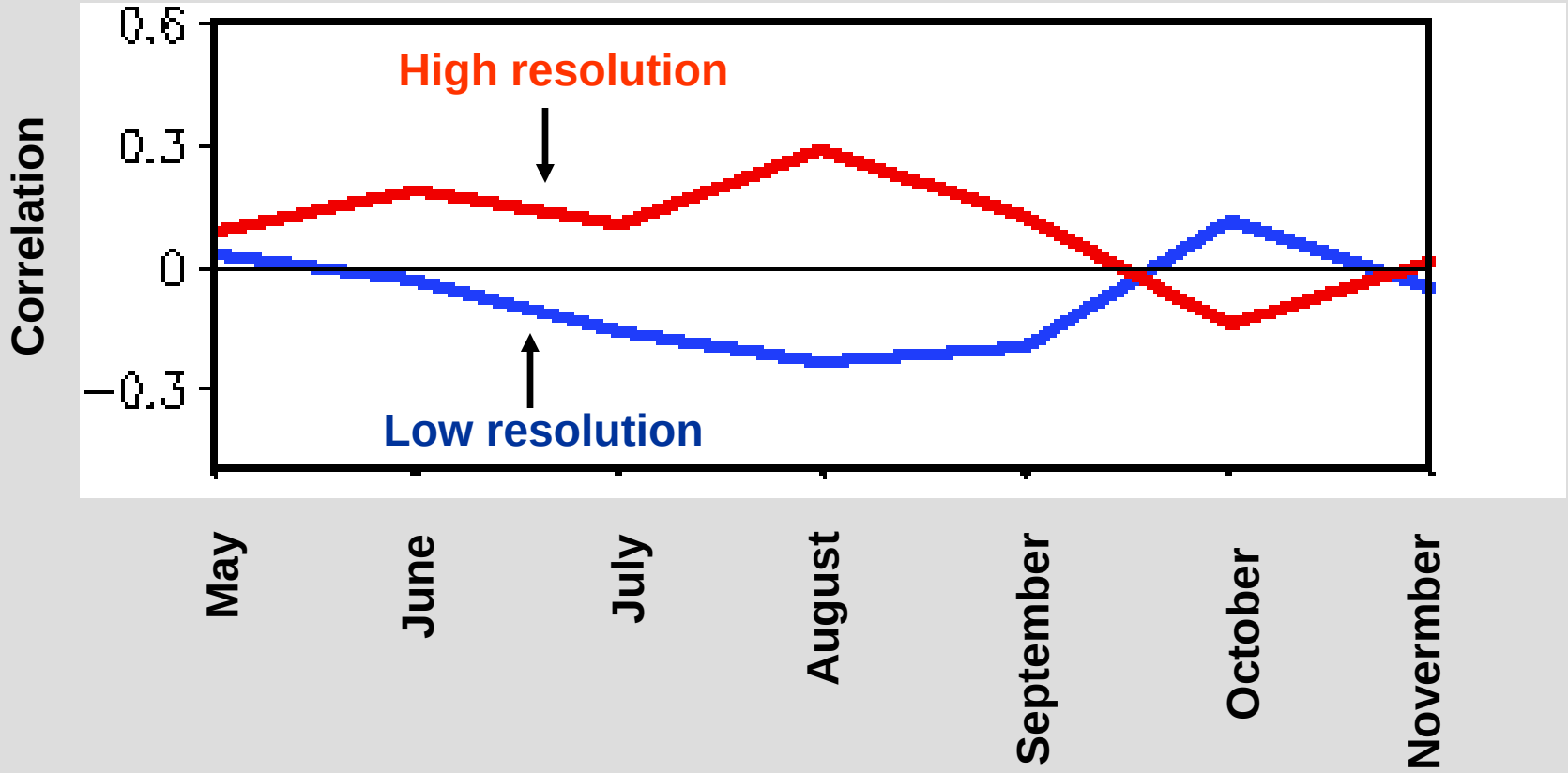
Low resolution global model



High resolution global model



Monthly precipitation correlation between NCEP seasonal forecast models and observations in northwest Mexico (1982-2008)

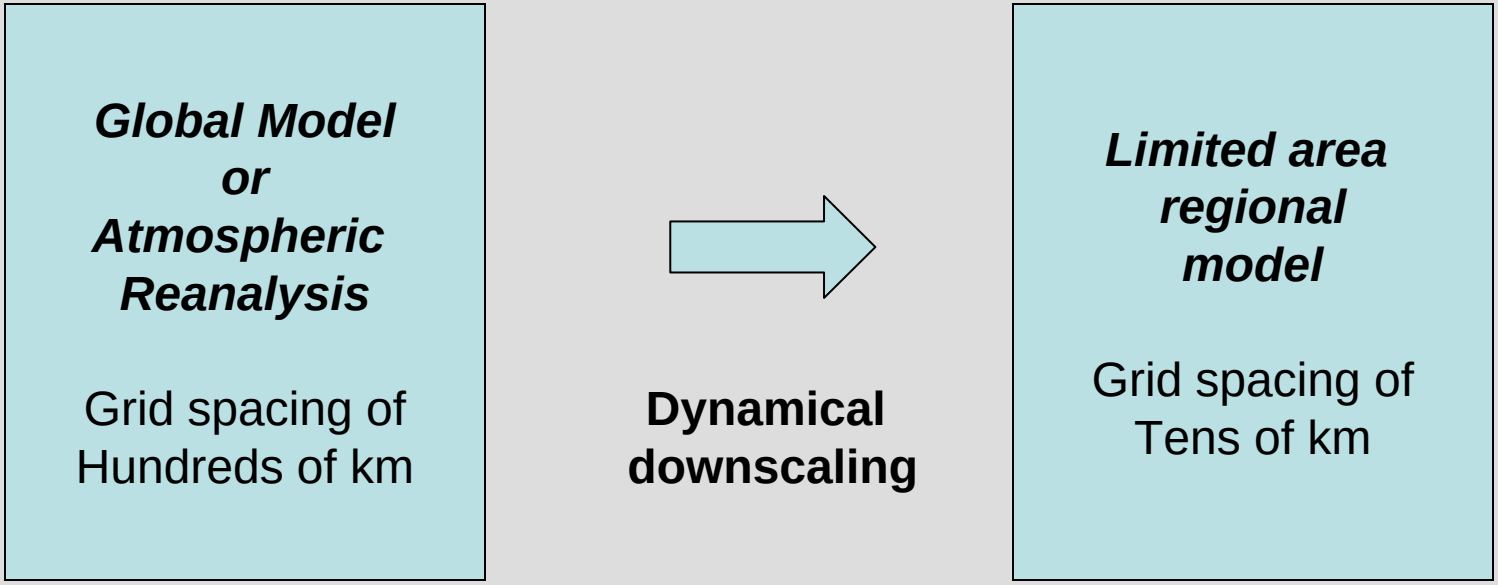


(Jae Schemm and Bhaskar Jha, NCEP)

Regional models are different becasue they require data at their lateral boundaries.

We’re using NCEP and IPCC models.

Value added by a regional atmospheric model

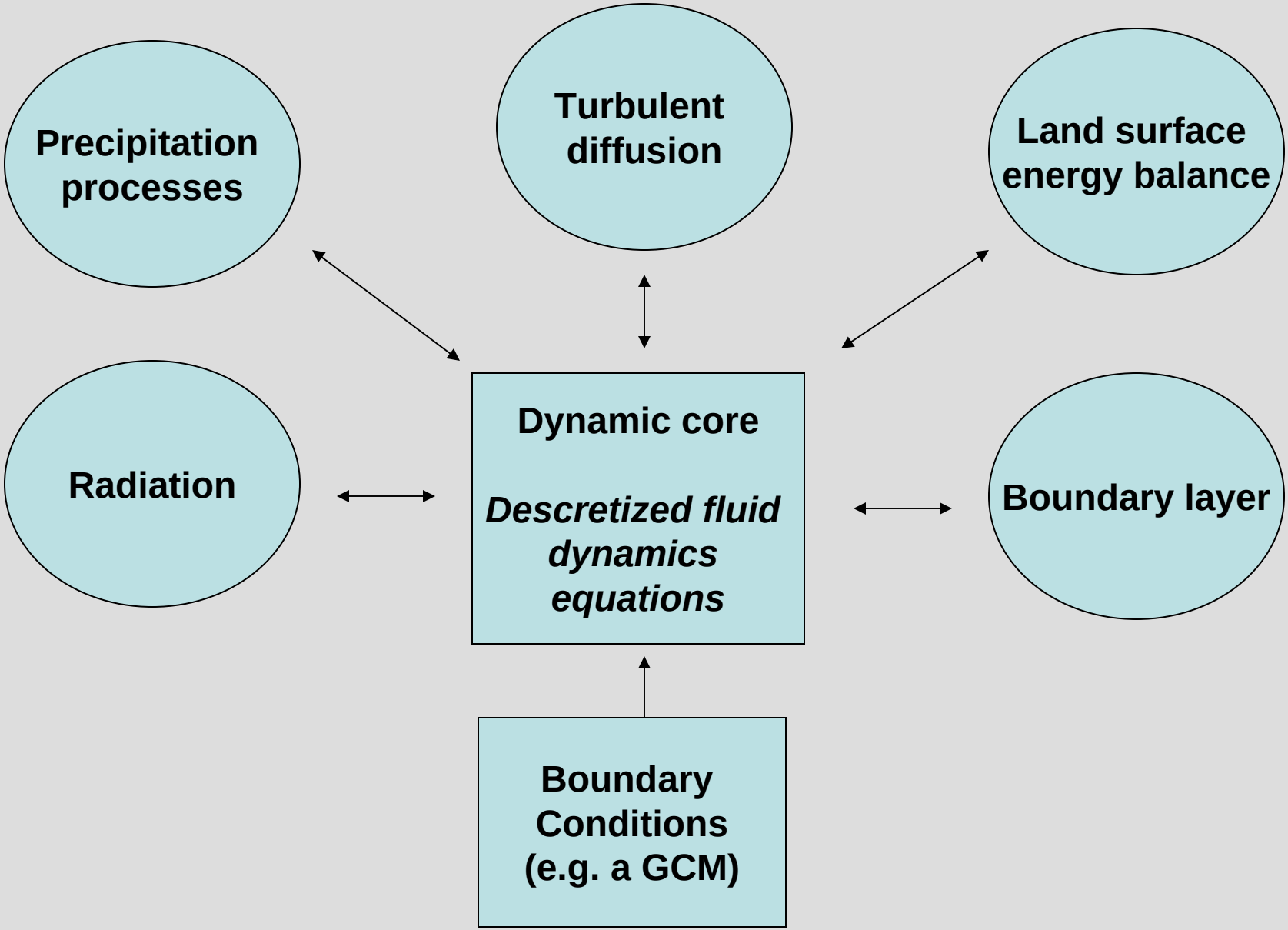


<u>Value added by this process</u>:

•Better representation of the land surface and atmospheric circulation

•Improved representation of atmospheric processes, like convective rainfall

What comprises an regional atmospheric model?



Use of WRF for Downscaling of CFS Reforecasts for Warm Season

The version of WRF we use is the Advanced Research WRF (ARW)

Model physical parameterizations consistent with those of the existing WRF NWP System at UA. Use NARR soil moisture as an initial condition.

Summer reforecasts specifically start at the beginning of April, May, or June of the given year for period 1982-2000. WRF simulations start at beginning of May or June and end in August. Only 3 ensemble members available per initialization period, unfortunately!

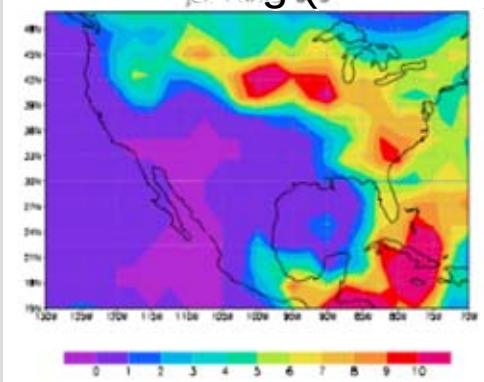
Data from NCEP reanalysis 2 is also being dynamically downscaled to assess the performance of the RCM assuming "perfect" boundary forcing.

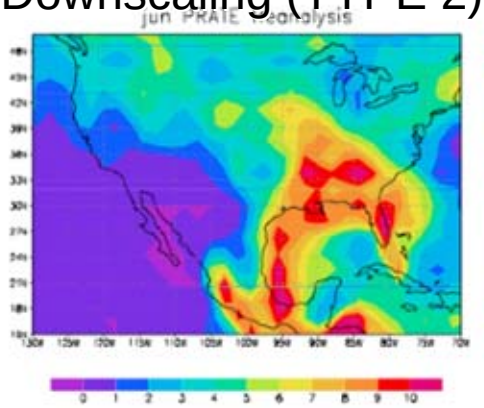
The domain for these simulations covers the contiguous U.S. with a grid spacing of 32 km.

CFS member Downscaling (TYPE 3)

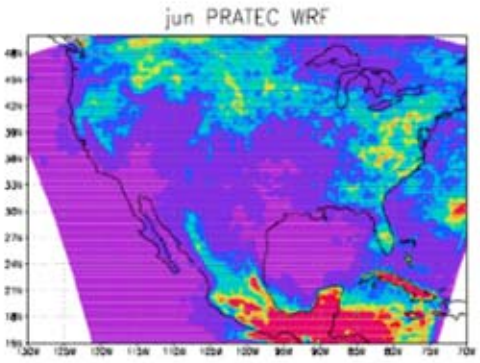
NCEP Reanalysis: Downscaling (TYPE 2)

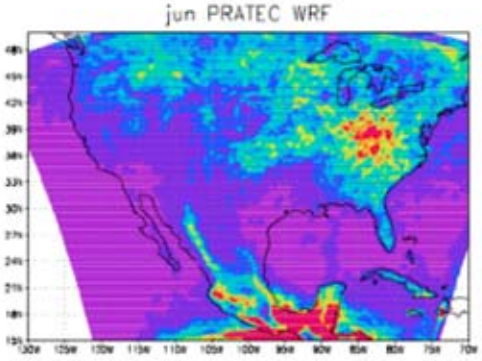
Original Global model



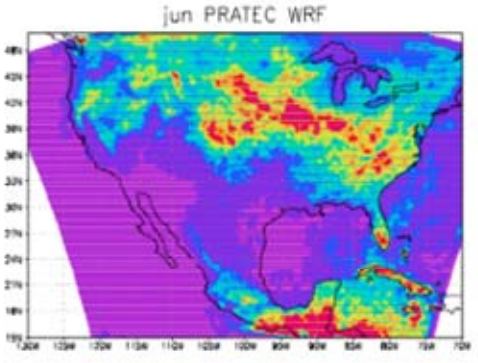


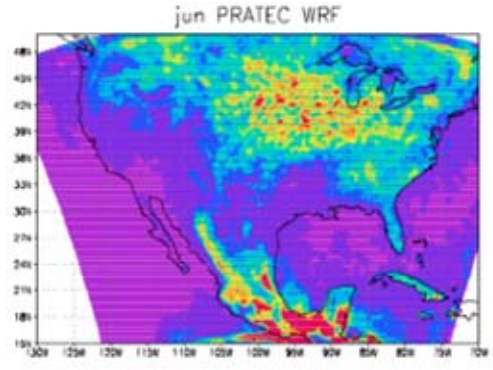
WRF Lateral boundary nudging only





WRF Spectral nudging

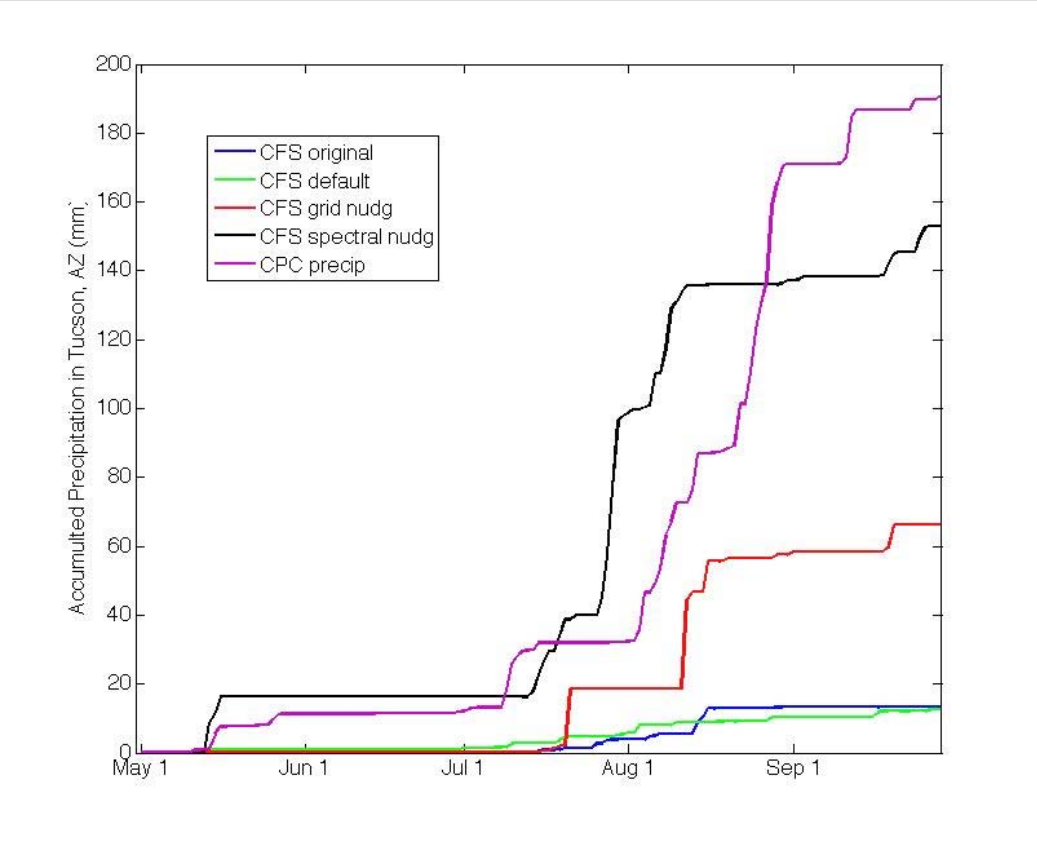




June precipitation solutions for one ensemble member (mm day^{-1})

1993 Summer precipitation Tucson, AZ

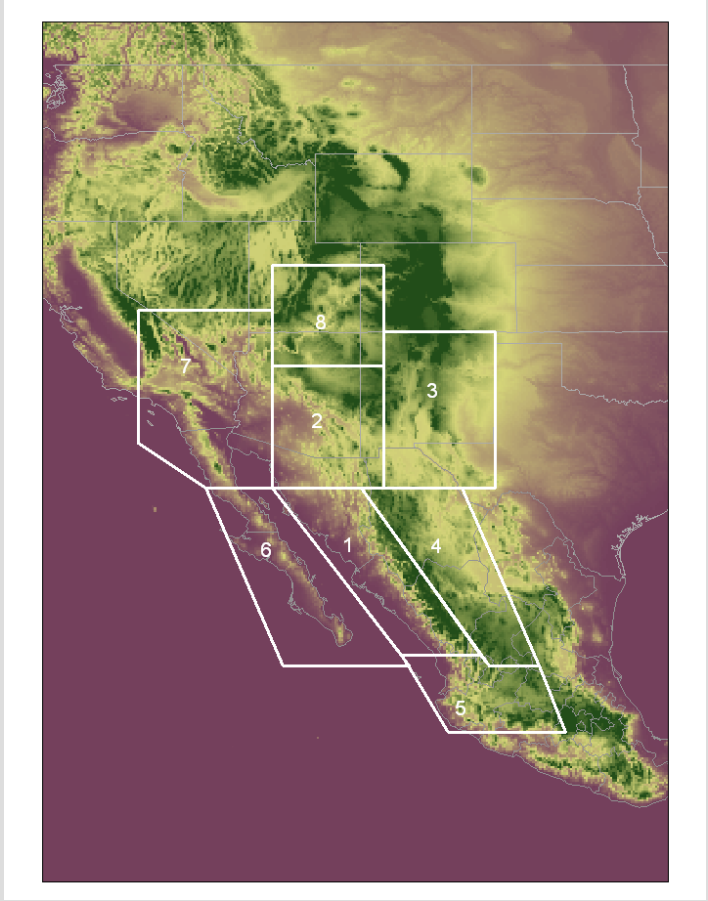
Single CFS ensemble member initialized in May

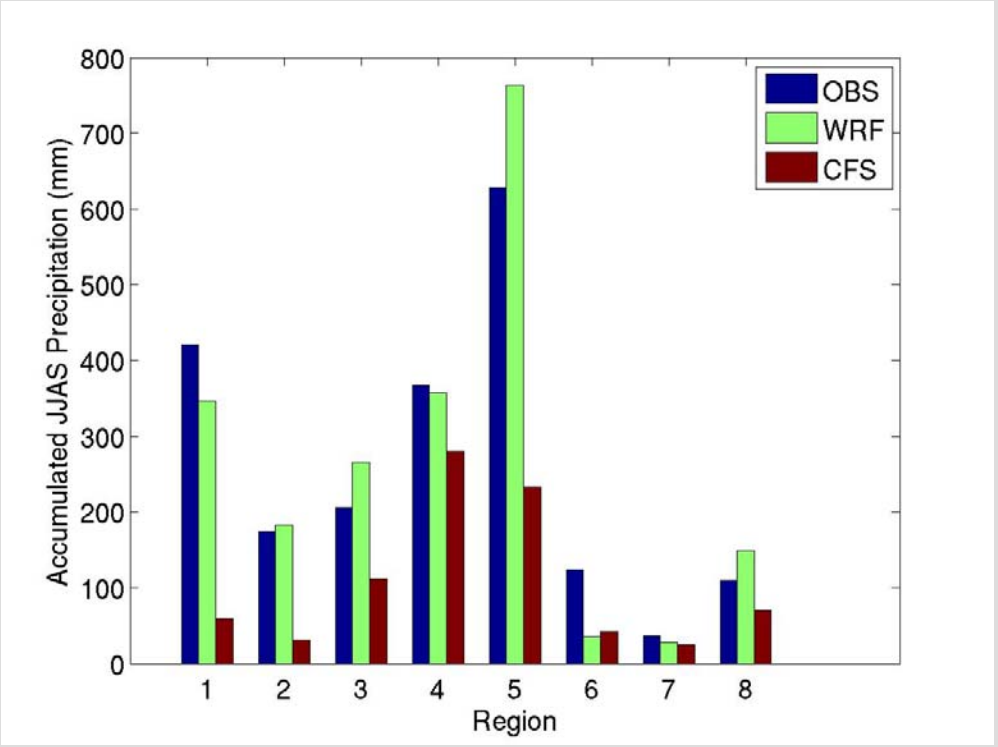


WRF downscaled simulation with spectral nudging gives best result!

Original CFS model and WRF-CFS downscaled with no interior nudging HAVE NO MONSOON!

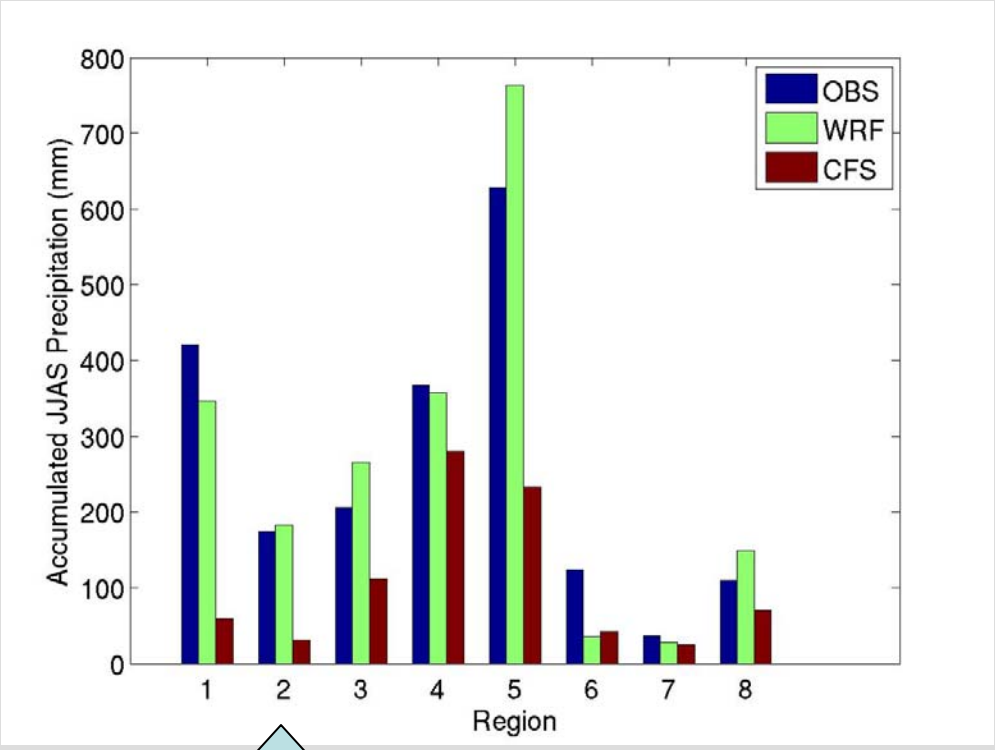
Climatology of WRF-CFS downscaled simulations with spectral nudging vs. original CFS and observations





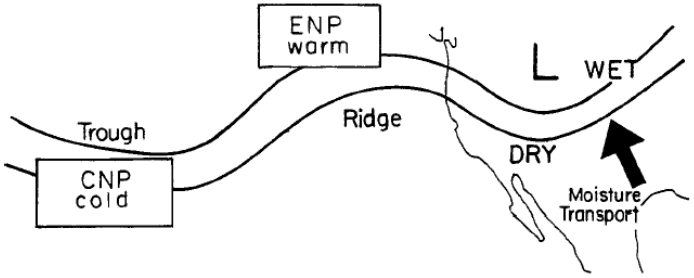
A better representation of the diurnal cycle of convection explains the dramatic improvement in precipitation by the RCM

Climatology of WRF-CFS downscaled simulations with spectral nudging vs. original CFS and observations



Southeast Arizona

Monsoon Ridge Position at Onset (Late June, July)



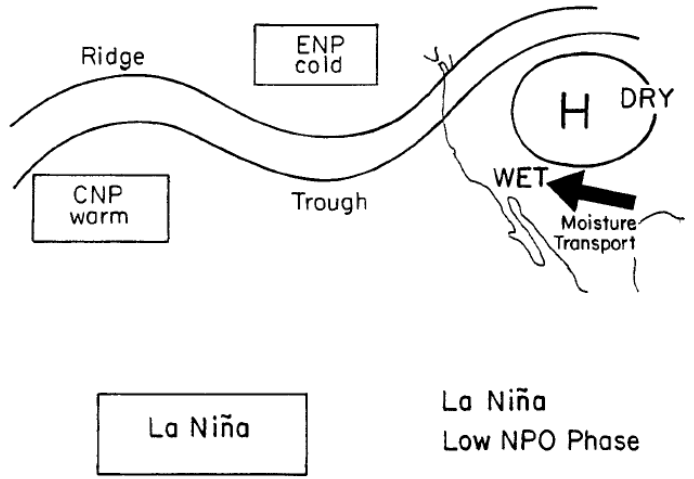


FIG. 14. Idealized relationship of monsoon ridge position and midlevel moisture transport to Pacific SSTs at monsoon onset.

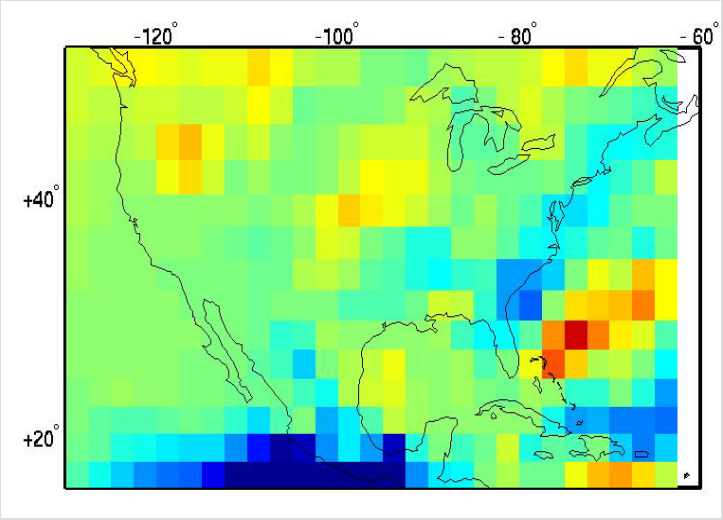
Climatology delayed

Climatology accelerated

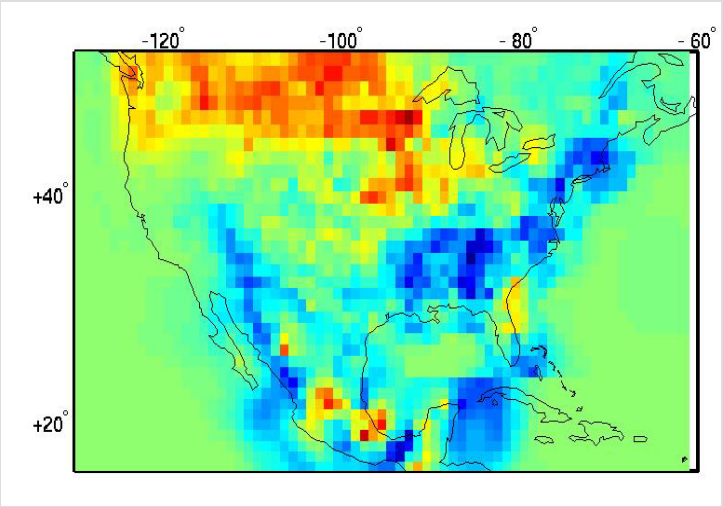
(Castro et al. 2001)

July Precipitation regression coefficient with index based on dominant Pacific SST modes

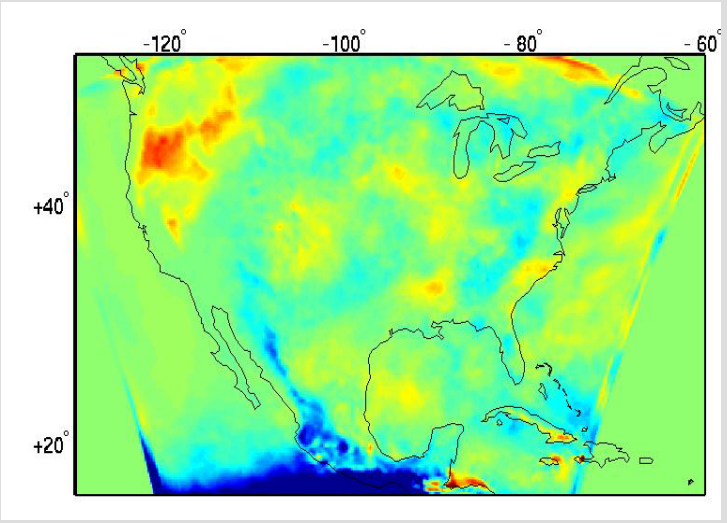
Original CFS Ensemble Average

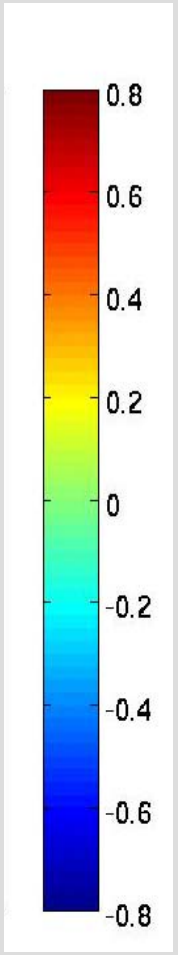


Gridded observed



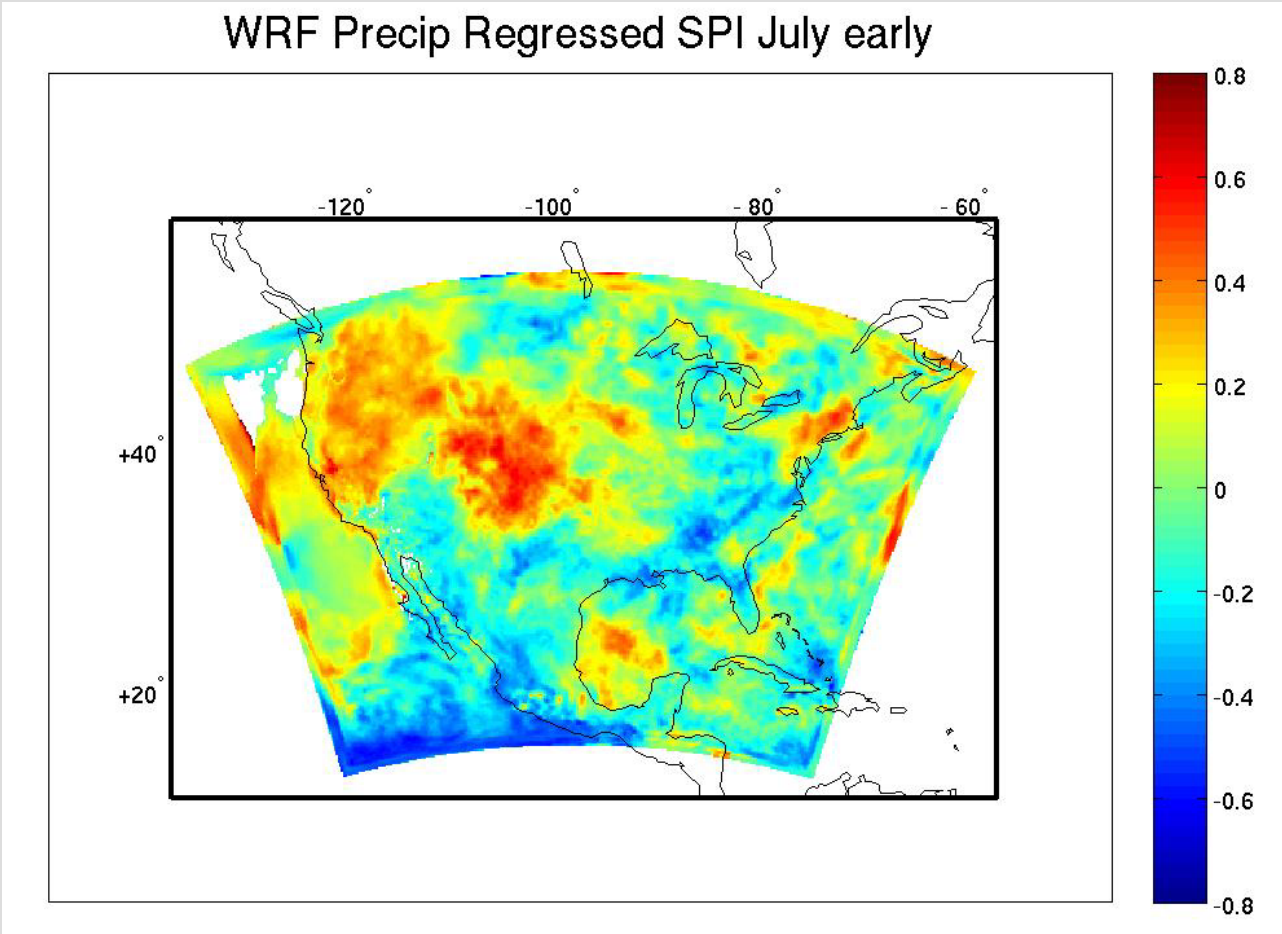
WRF-CFS Downscaled Ensemble Average





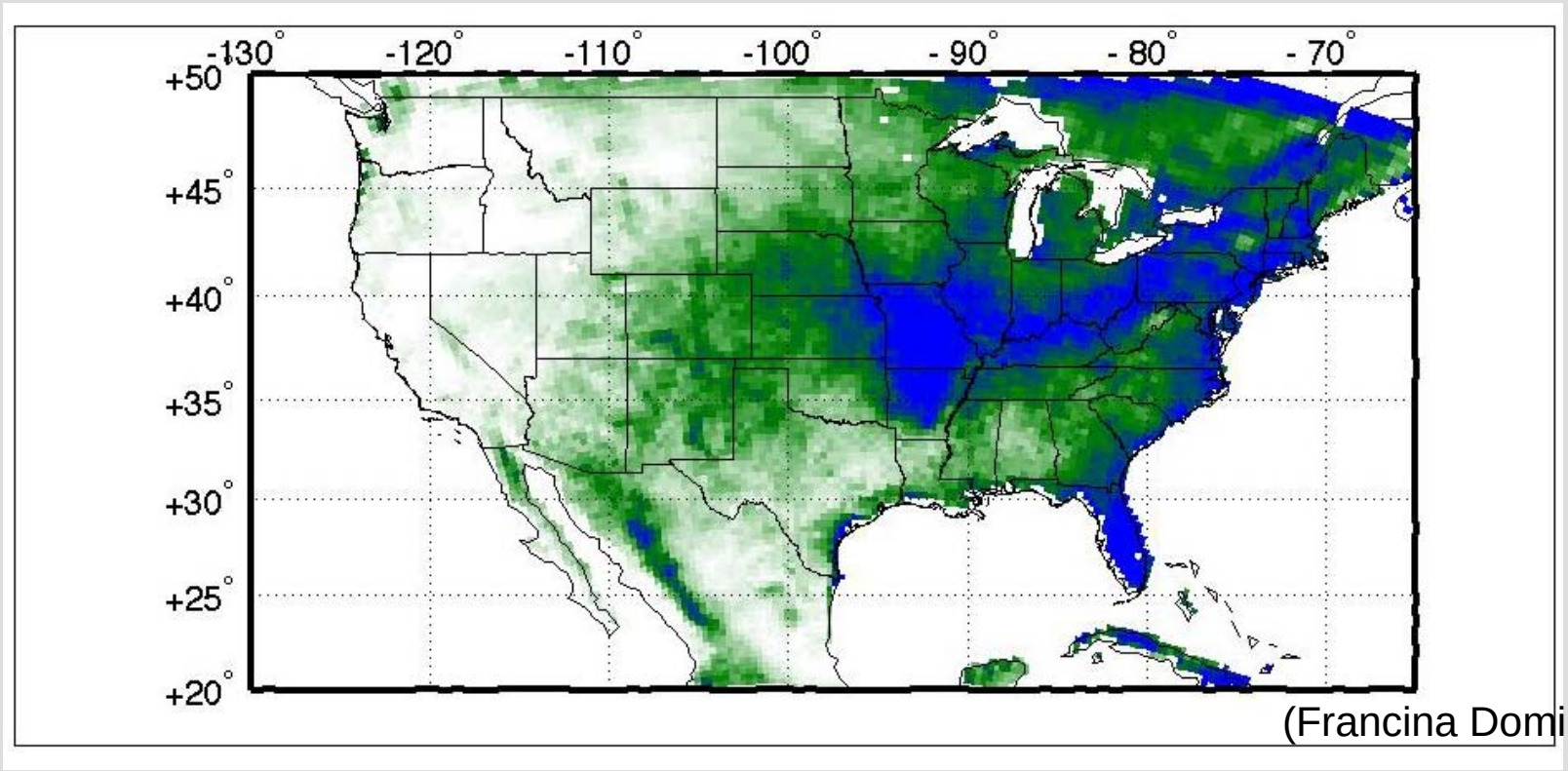
mm day^{-1}

Hot off the press…
How does it improve using SPI technique as a bias correction?



Correlation coef.

We are also using WRF in a similar way to make climate change projections…



(Francina Dominguez)

Example of WRF-simulated precipitation in July 2010. This simulation uses the HadCM3 model as the driving GCM.

We anticipate that all climate simulations with WRF will be completed and analyzed within one or two years.

It's very clear that there is a great need for this type of information for decision making with respect to resources in Mexico and the United States.

Conclusiones

Aunque el monzón afecta la gran área del suroeste del EE.UU. y el noroeste de México, la precipitación es de tormentas que ocurre en la escala local.

Modelos actuales globales no representan bien los procesos que influyen la precipitación durante el verano. Estos incluyen el ciclo diurno de convección, variabilidad dentro del monzón, y la variabilidad interanual.

Por eso, no debemos confiar en los productos actuales que dependen de modelos globales de baja resolución para representar el monzón norteamericano. Es muy probable que esta conclusión sea la misma en otras regiones durante el verano (e.g. el monzón del America del Sur).

Modelos (globales o regionales) de alta resolución mejoran la representación del monzón de tal manera que sus resultados se pueden utilizar para tomar decisiones. Estos productos estarán disponibles dentro de pocos años.

Taller de los Impactos del Monzón

IPGH aprobó esta propuesta de la Comité Geofísica para un taller en 2009. Esta propuesta tienen investigadores de México y los EE.UU. (Drs. Jimmy Adegoke y Tereza Cavazos). También les estoy ayudando a ellos en sus esfuerzos.

Solamente $7000 fue aprobado y estos recursos no son suficientes para los gastos del taller. Ya buscamos fondos adicionales de fuentes estadounidenses.

Se pidió una extensión del taller hasta 2010. Algunos lugares para conducirlo incluyen:

- **En la Cuidad de México o Costa Rica como un taller apartado (abril hasta mayo?)**
- **En Brasil durante la reunión del AGU más tarde**

¿¿Le interesa apoyar este taller a un miembro de la Comité Geofísica??