Changes in North American Monsoon precipitation in a warmer climate

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Motivation

- Monsoons and drought affect all aspects of life
  - Especially agriculture
- The most rapidly growing places in the U.S. are potentially some of most affected by changes to the monsoon system
- Modeling is used to predict future changes in water availability
- Does climate change mean changes in monsoonal patterns?
- Could drought be headed our way? And with it, possible stress for agriculture?

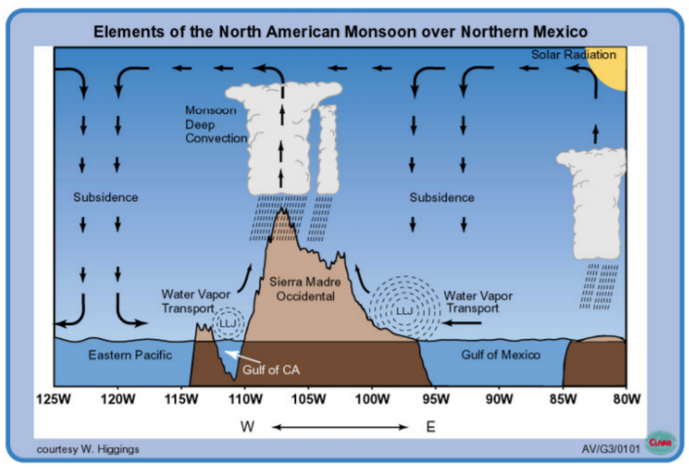

Figure 1:Schematic taken from a paper released by the Climate Prediction Center over the NAM (CPC)

Introductory Information

- Monsoon, also generally known as 'rainy season'
- North American Monsoon exists, but on a much smaller scale than the Asian Monsoon due to less pronounced seasonal reversals of winds
- Can be dependent on El Niño and La Niña phenomena

Methodology

Data Sources

The data that was used to create the maps and plots shown was extracted from:

- SP-CESM – Model data from 2 SP-CESM simulations were used. Specifically, we used Preindustrial and 4XCO2 runs, each with 10 years of simulated data.
- CMORPH – Observed data extracted from the database that was created using the "NOAA CPC Morphing Technique." The technique produces global precipitation analyses with a very high resolution. It uses precipitation estimates from low orbiter satellite microwave observations exclusively (Joyce, 2004)

Data and modeling

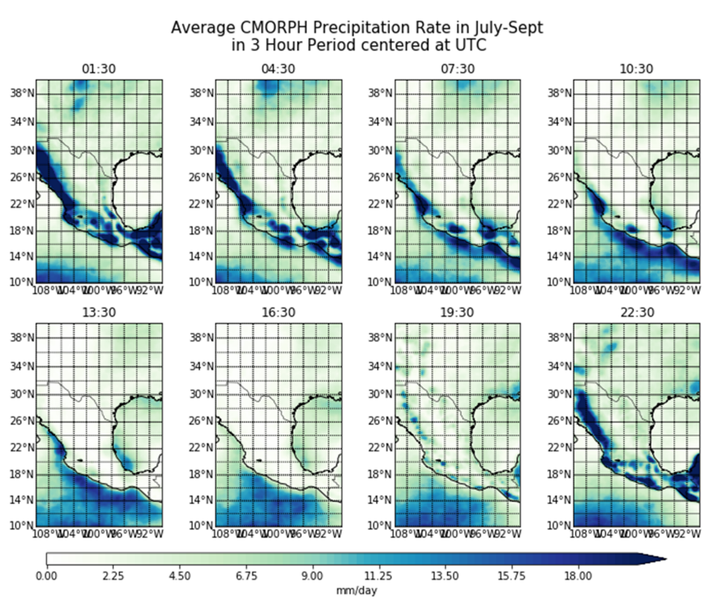

Figure 2:Composite shown above shows average precipitation amount (in mm/day) at 3 hourly intervals over the course of the monsoon season (July-Sep)

- Monsoon region of 18-33°N and 102-112°W was chosen
- Data was averaged and plotted over this region

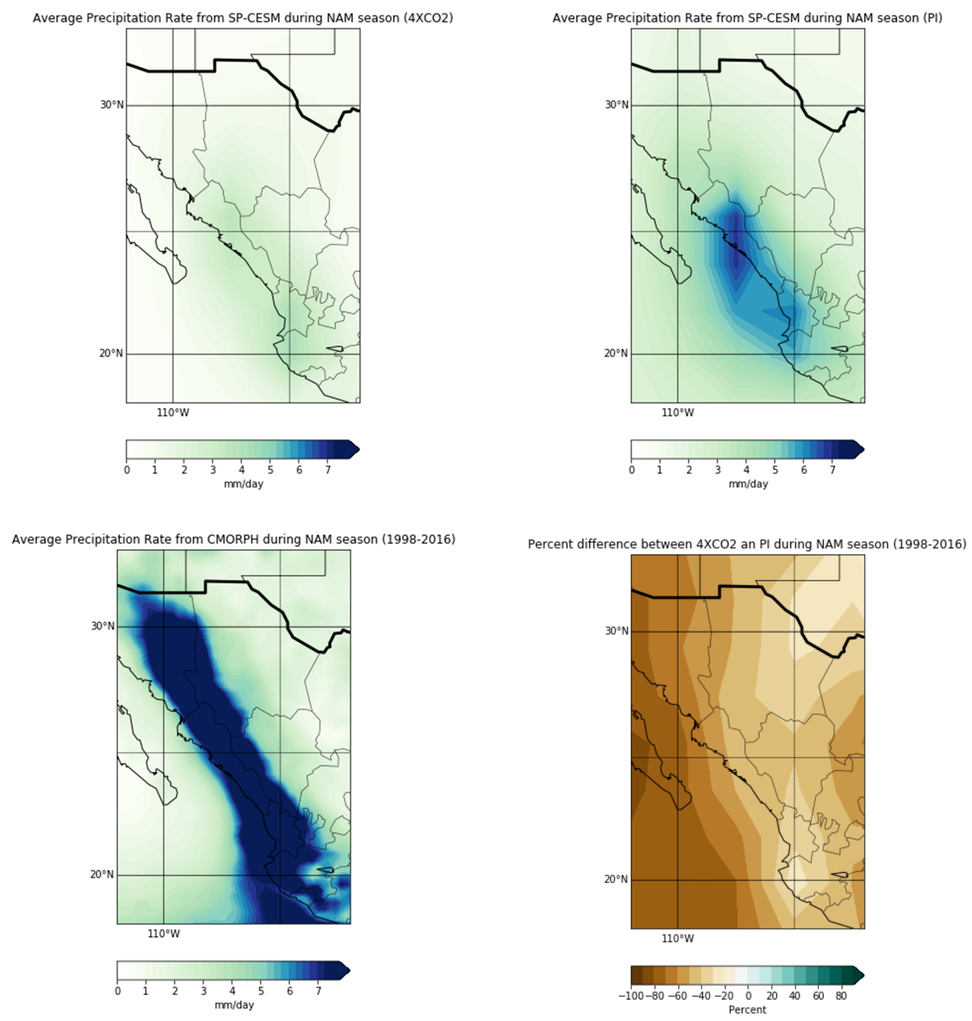

Figure 3:Composites of average precipitation data from all three data sources

- It is clear from the maps that the observed data shows significantly more precipitation than either model
- Both models don't really resolve the mountains in Mexico
- 4xCO2 shows dramatic precipitation decreases relative to the control
- Latitude vs. Time plots (Figure 4) show where and when during the season rainfall occurs
- They clearly show that CMORPH has a well defined monsoon season
- The preindustrial run has a stronger concentration of precipitation during late Fall and Winter
- 4xCO2 shows dramatic lower precipitation, but also shows a concentration in winter

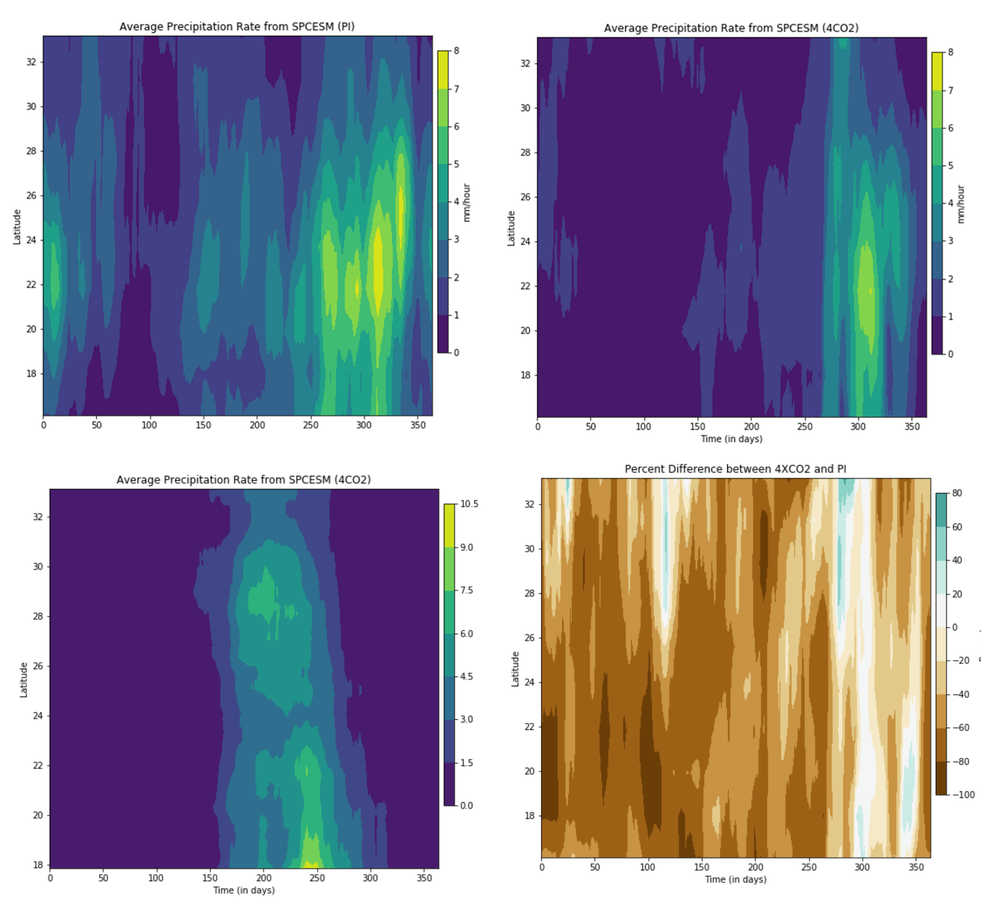

Figure 4:As with Figure 3, each set of data was used to create a latitude vs. time plot. These plots allow us to see concentrations of precipitation and how they change throughout the year at different latitudes.

- Plots with brown/blue color bar:
  - These plots are percent difference between PI and 4xCO2
- Over almost all seasons and latitudes 4xCO2 has less rainfall
- Only precipitation increases are in late Fall, primarily to the north and south of Latitude vs. Time plot
  - Could the missing moisture be outside of the NAM region?

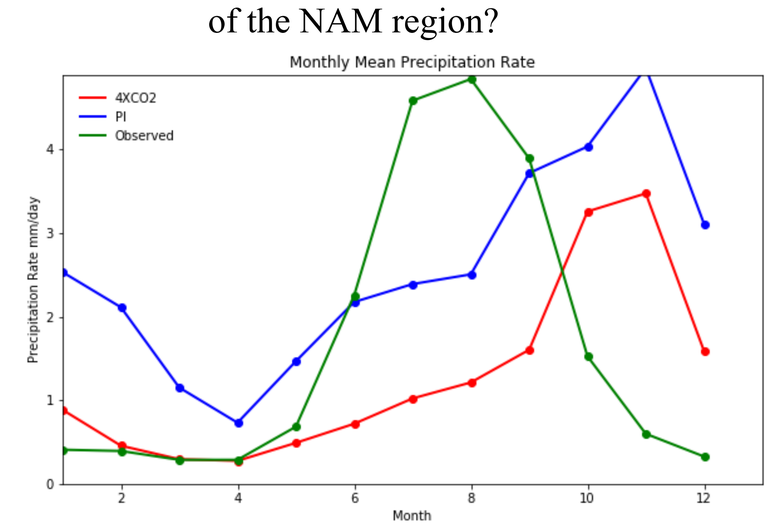

Figure 5:Above plot shows comparison between observed precipitation data and both model runs of data.

Conclusions

- Sp-CESM indicates that North American Monsoon precipitation decreases strongly in a 4xCO2 climate relative to preindustrial
- Some modest increases may occur late in the monsoon season (e.g. October)
- The peak rainfall amount occurs after the JAS season in the models relative to CMOPRH, providing a caveat to the results
- Rainfall is spread more evenly throughout the year (i.e. less of a seasonal cycle) in 4xCO2 climate
- Supports the conclusion of Eric's previous paper across multiple CMIP5 models
- Drier early summer and wetter fall (Maloney, et al, 2013)•Differs from research about Asian Monsoon:
- Rising temperature/CO2 levels seem to decrease amount of precipitation
- Opposite of what was concluded about Asian Monsoon (Turner, n.d.)

Future Work

- Comparisons with other models
- Looking at other variables, such as temperature and pressure

References and Acknowledgments

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