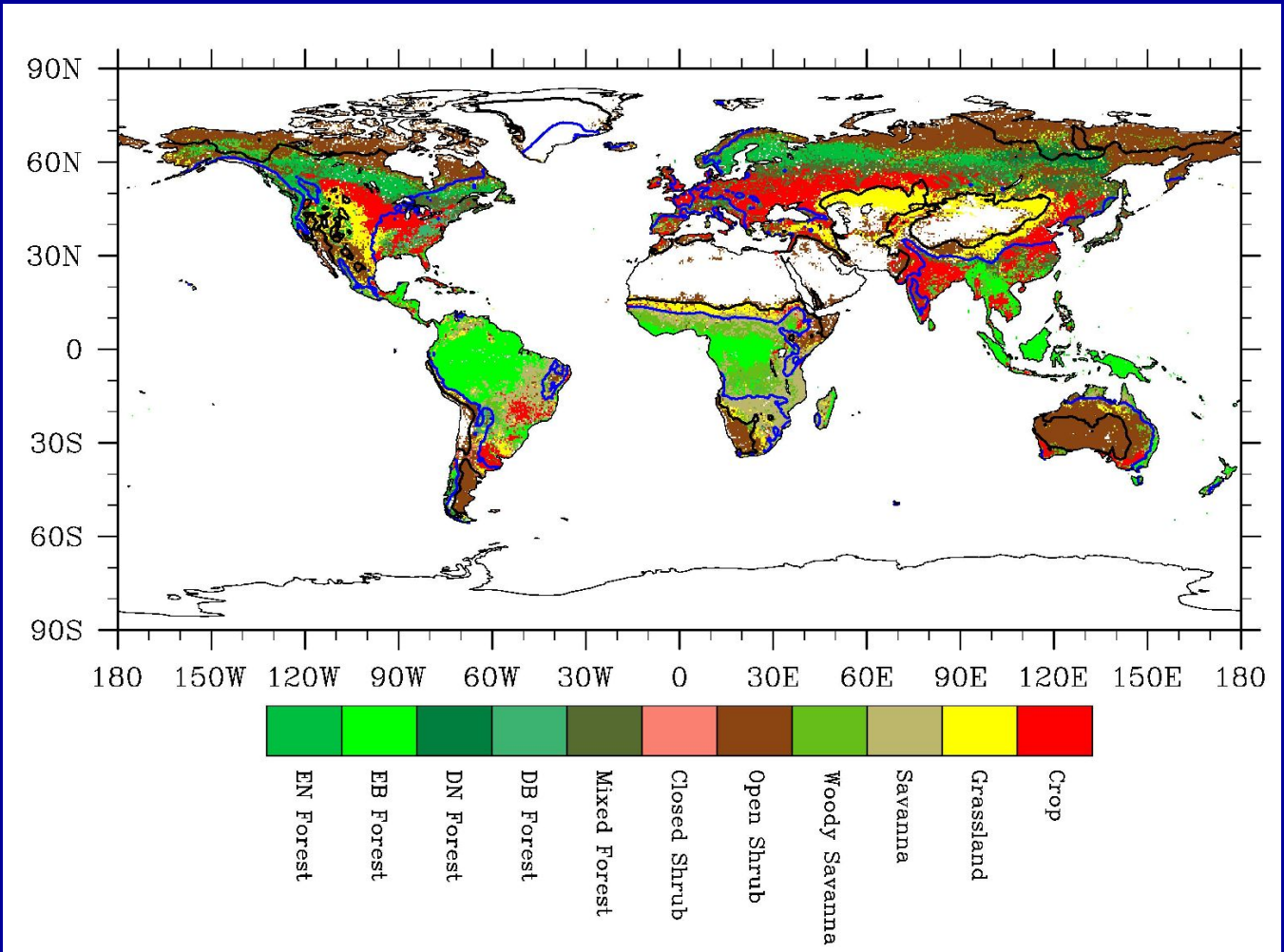
Growing Temperate Shrubs over Arid and Semi-arid Regions in NCAR CLM-DGVM

Xiao-Dong Zeng, Xubin Zeng, and Michael Barlage
Department of Atmospheric Sciences
The University of Arizona, Tucson

Goal: Develop a shrub sub-model for CLM-DGVM so that shrubs can grow properly over global arid and semi-arid regions.



Observational characteristics of shrubs

In arid and semi-arid regions, summer is usually very hot and annual precipitation is limited (300mm or less) and mainly concentrated in specific seasons. Shrubs, therefore, develop two traits: high tolerance to drought and high temperature

1. Leaves respond quickly to rain
2. Relatively high efficiency in soil water extraction
3. Expand more horizontally than vertically
4. Relatively low LAI and large horizontal root zone

Observational characteristics of shrubs

Shrub disadvantages:

- Due to low LAI, annual shrub-covered productivity is small
- Maximum photosynthesis under optimal T and SM is smaller than grass and tree

Result: relatively slow growth rate of shrubs

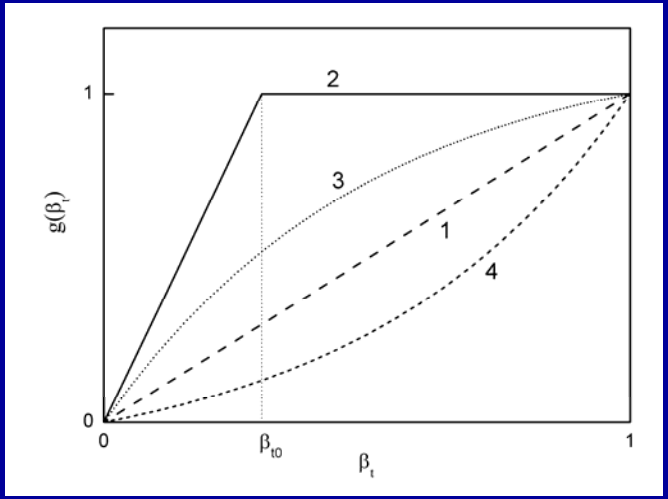
	Tree	Shrub	Grass
Growth rate	Medium	Low	High
Height	Tall	Medium	Short
LAI	High	Low	Medium
Drought tolerance	Low	High	Medium
Rain event leaf response	Slow/medium	Quick	Quick

Shrub Sub-model

1. Drought tolerance:

$$V_{\max} = V_{\max 25}(a_{v\max})^{\frac{T_v - 25}{10}} f(T_v) g(\beta_t)$$

Shrubs maintain high level of photosynthesis even in drought

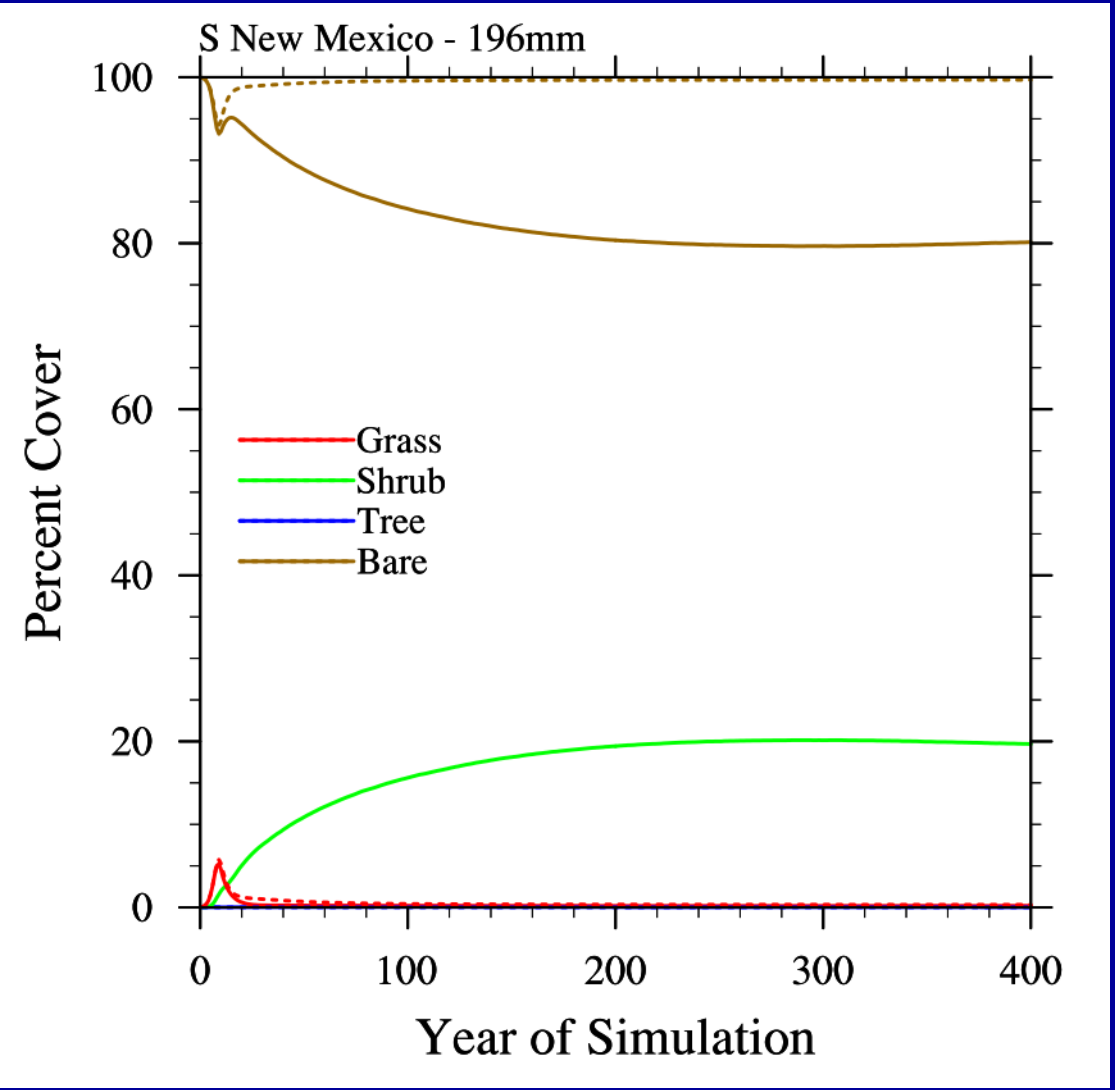


2. Phenology: In arid and semi-arid regions, the growth of temperate shrubs is mainly limited by soil water availability rather than T_{air}. Therefore, temperate shrubs are set to raingreen and keep a relatively high LAI in the wet season for high photosynthesis and low LAI in the dry, hot season to avoid high respiration.

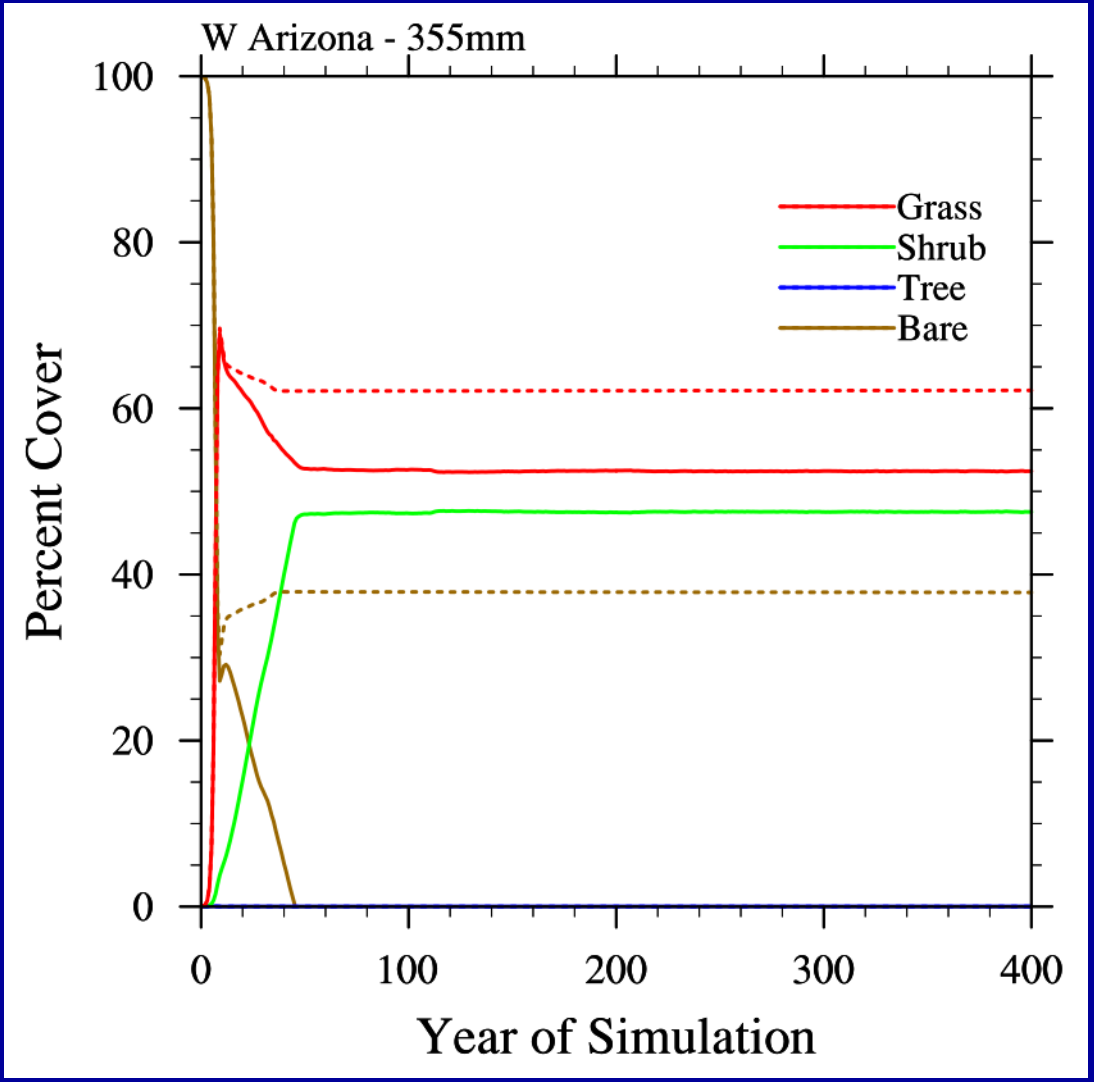
3. Plant morphology: parameters changed to be more appropriate

4. Competition: due to slow growth rate, shrubs cannot effectively compete with trees and grass when water is sufficient. New hierarchy: tree - grass - shrub

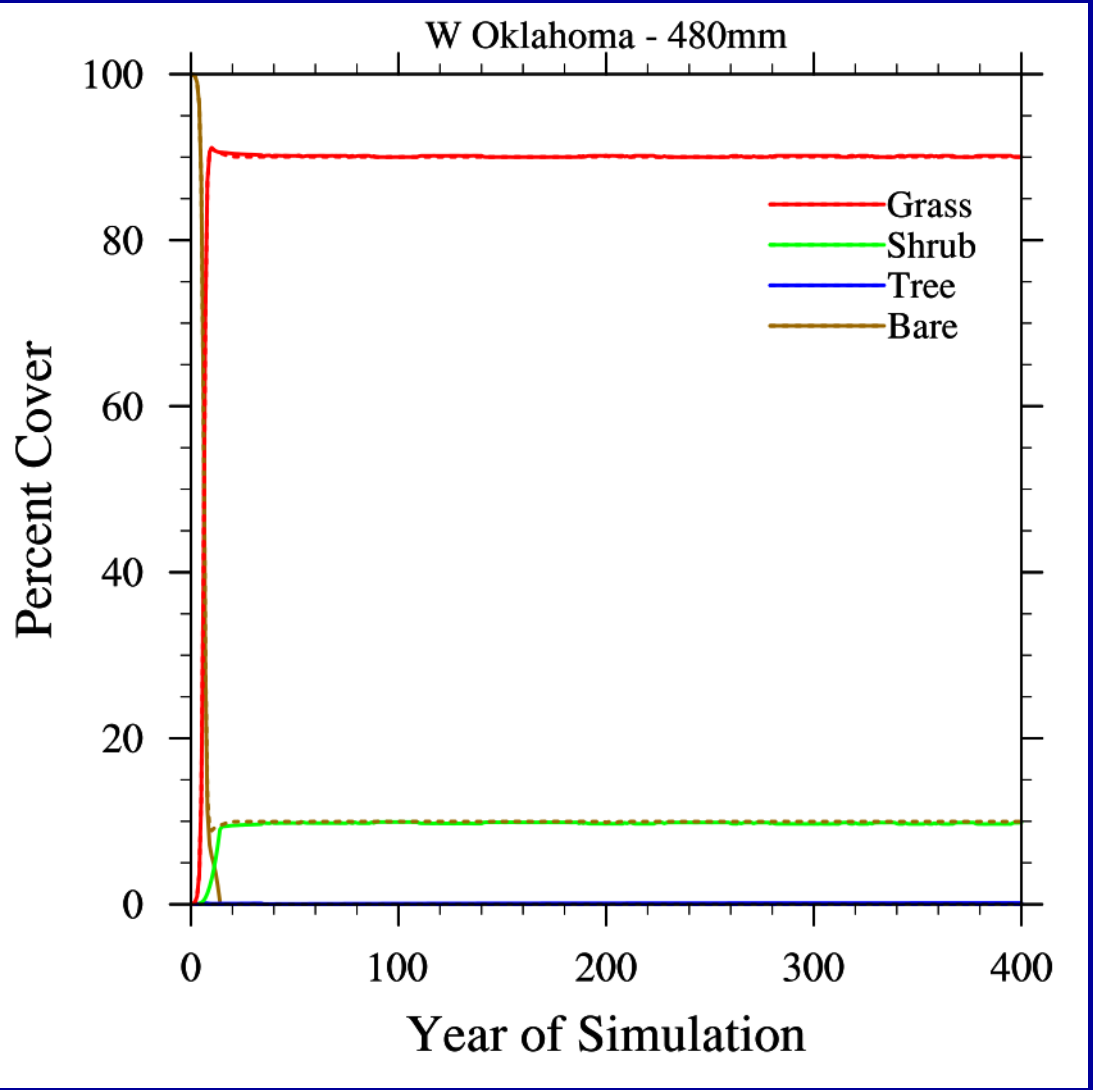
Cell Results: New Mexico (105.5W,32.3N)



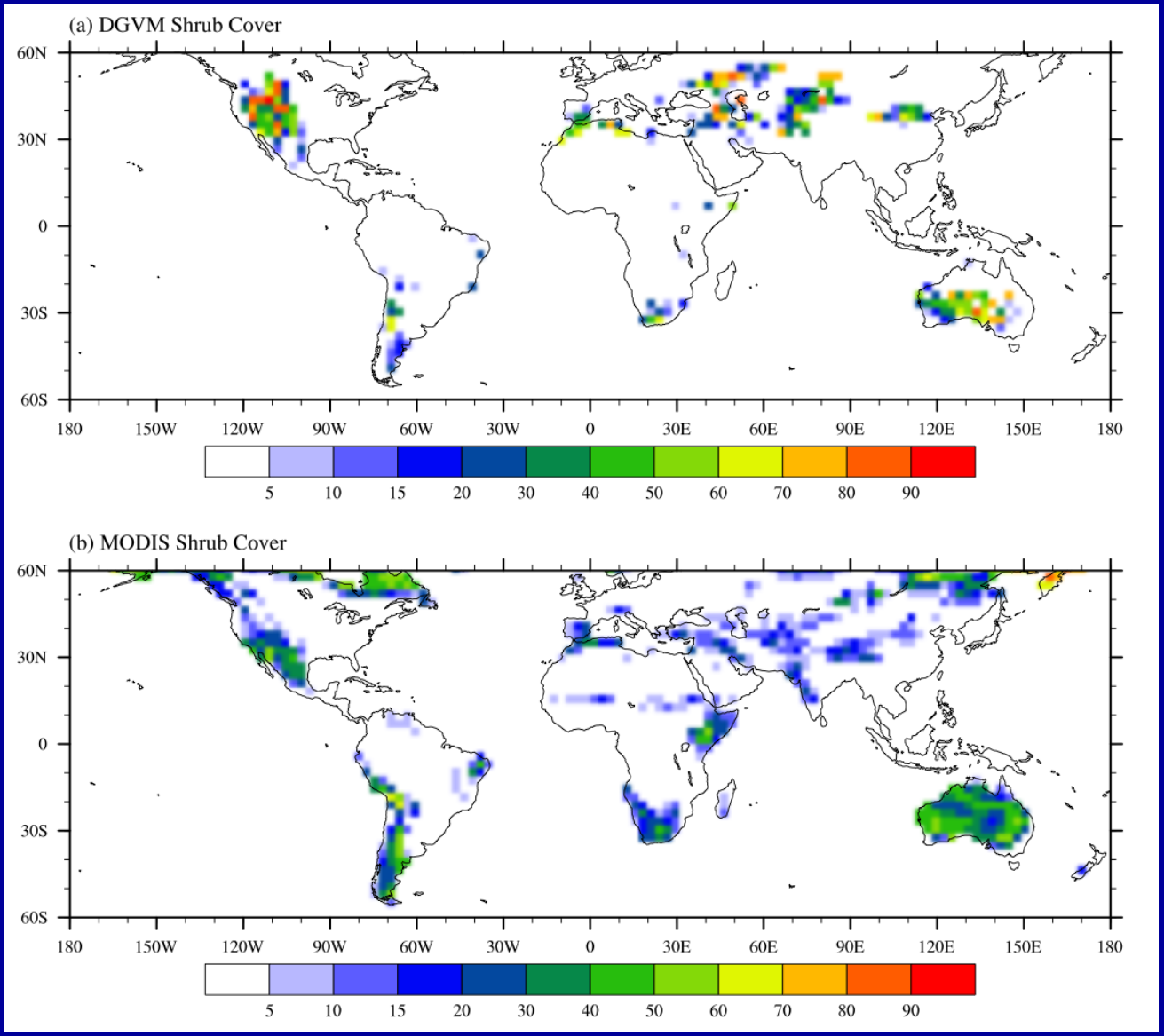
Cell Results: Arizona (111.1W,35.2N)



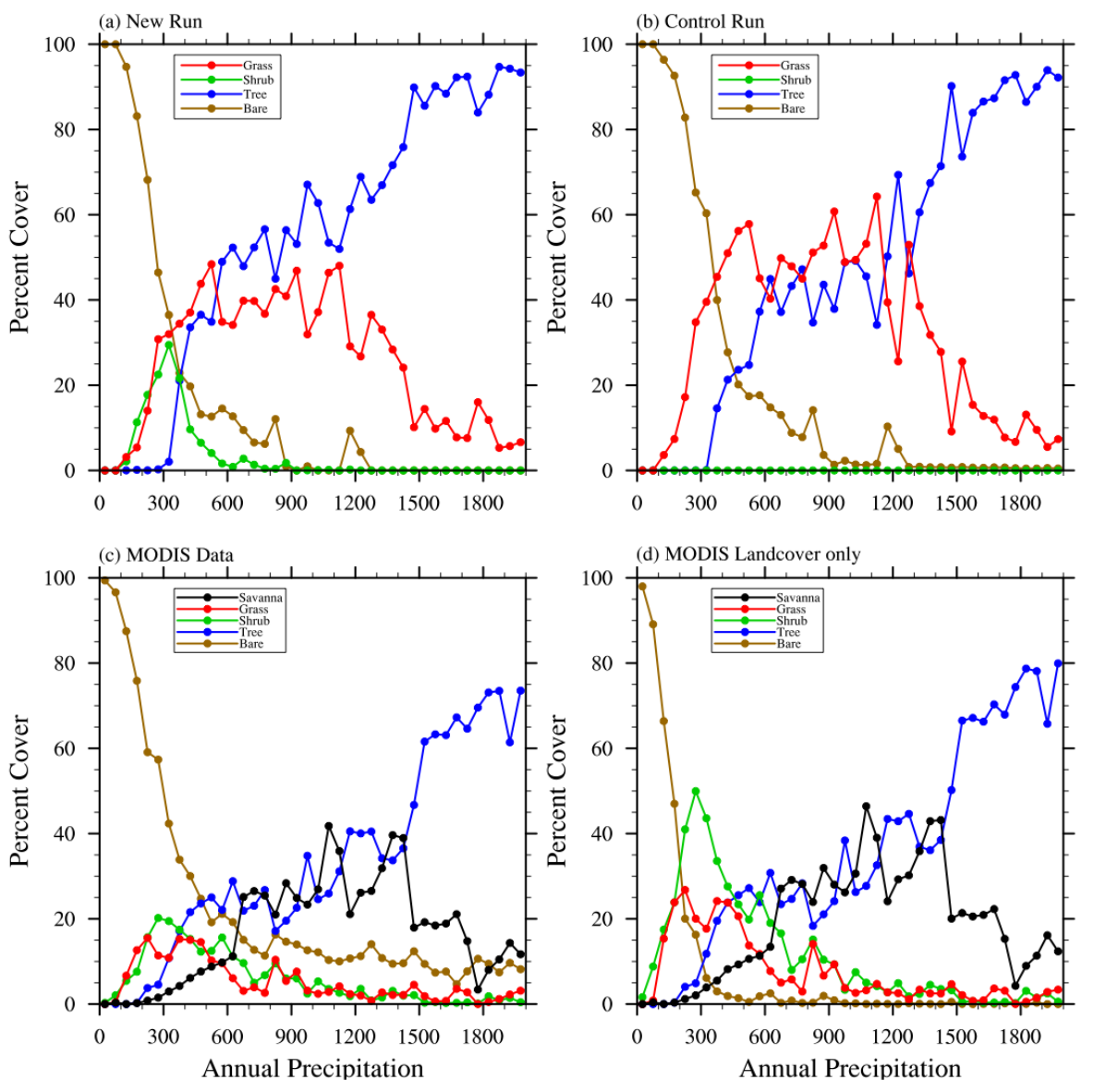
Cell Results: Oklahoma (99.8W, 35.2N)



Global Results



Global Results



Percent cover as a function of annual precipitation.

- Blue: tree
- Red: grass
- Brown: bare
- Green: shrub
- Black: savanna