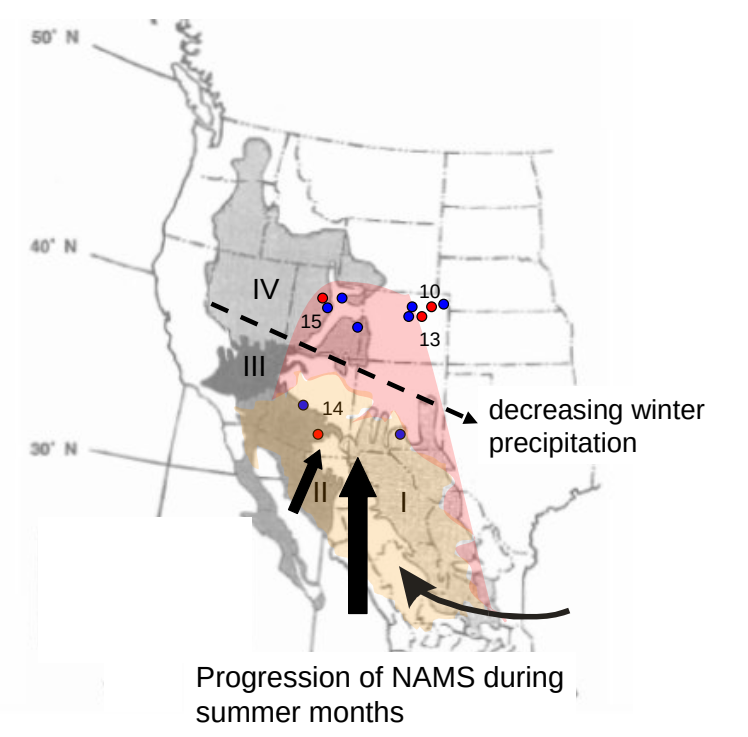
The North American Monsoon (NAM) Macrosystem



Progression of NAMS during summer months

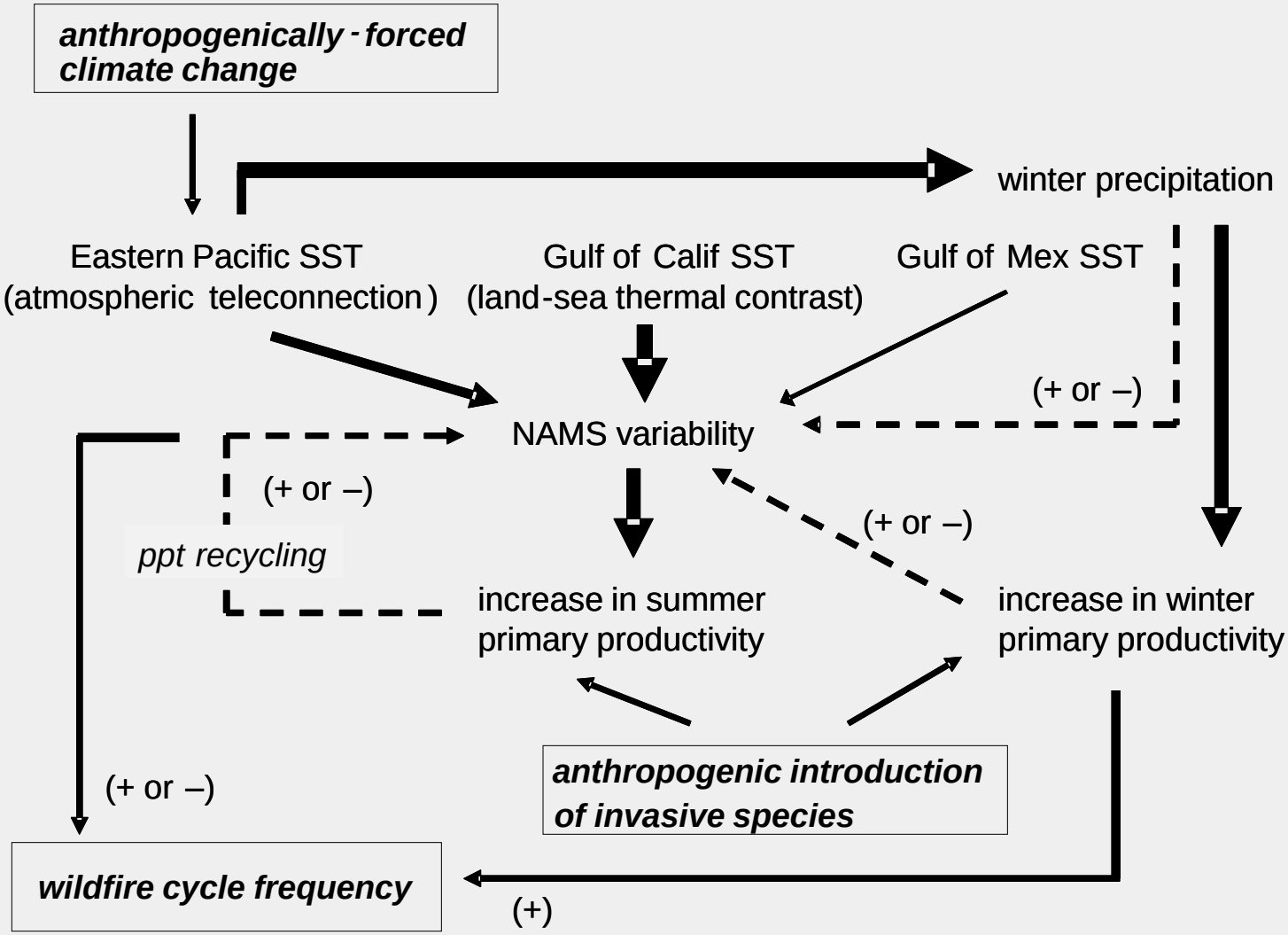
P.I. Russ Monson
University of Arizona

Chris Castro
Francina Dominguez
Xubin Zeng
Jiming Jin
Dave Gochis

Guo Yue Niu
Deb Peters
Julio Betancourt

Tom Swetnam
Connie Woodhouse
Steve Leavitt
Jim Ehleringer

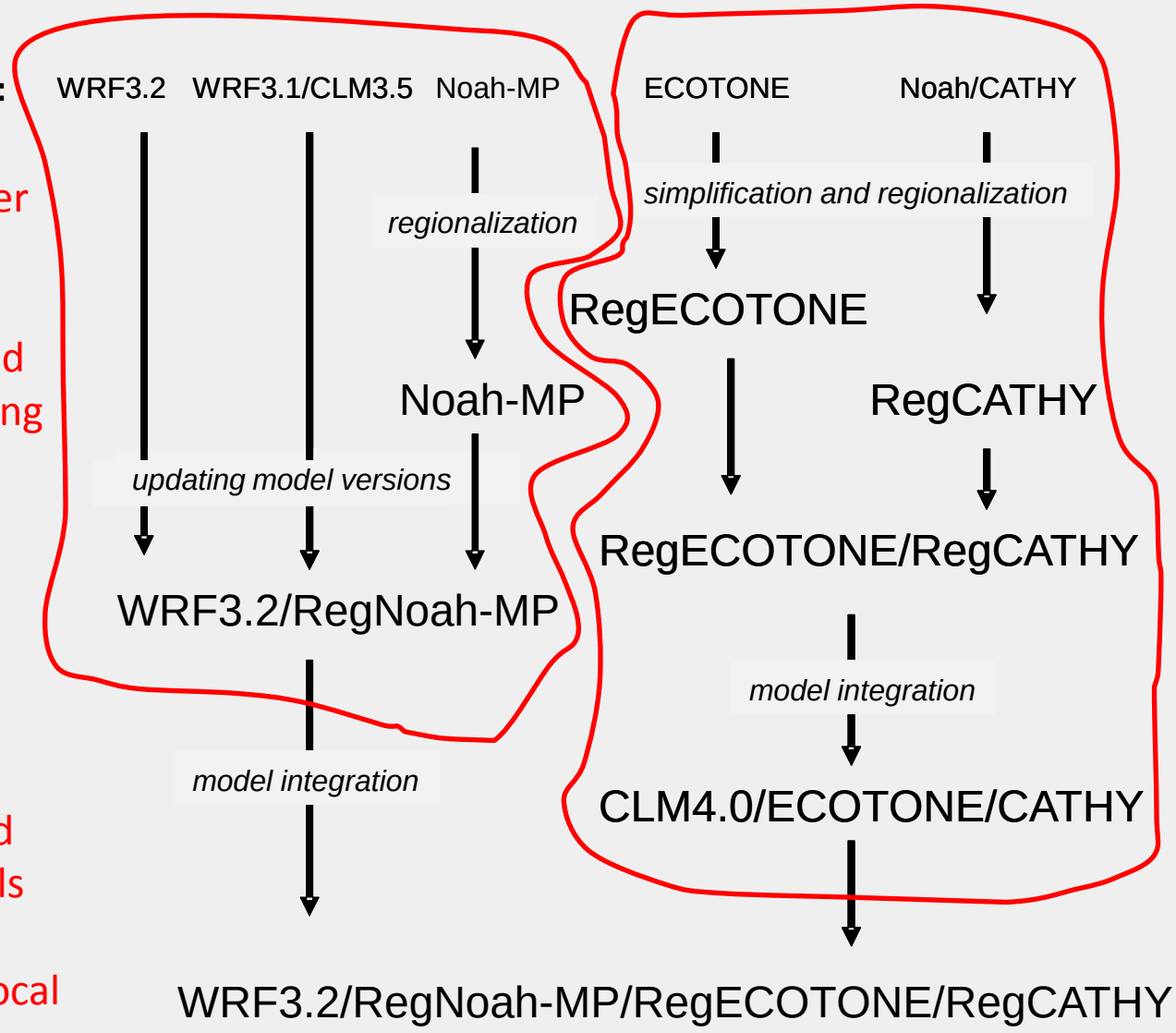
Hypotheses concerning high-frequency climate variation as a mechanism for connectivity and synchronization within the macrosystem



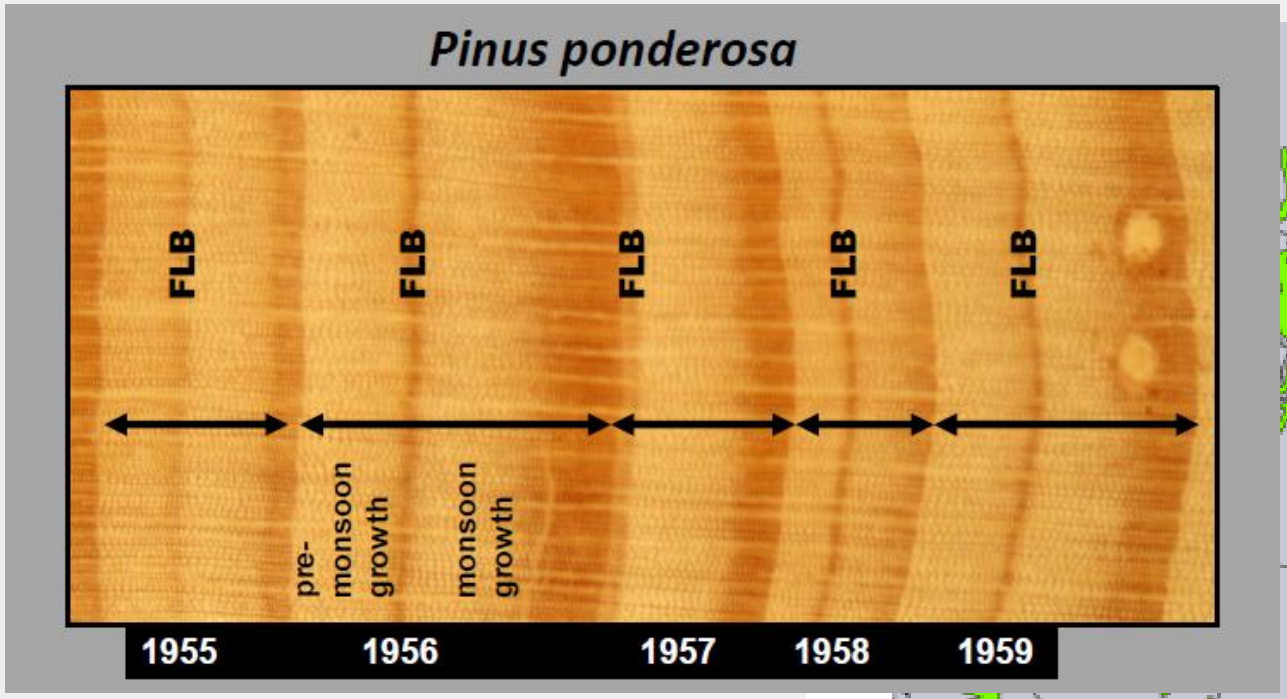
Designing Models Capable of Resolution at the Macrosystem Scale

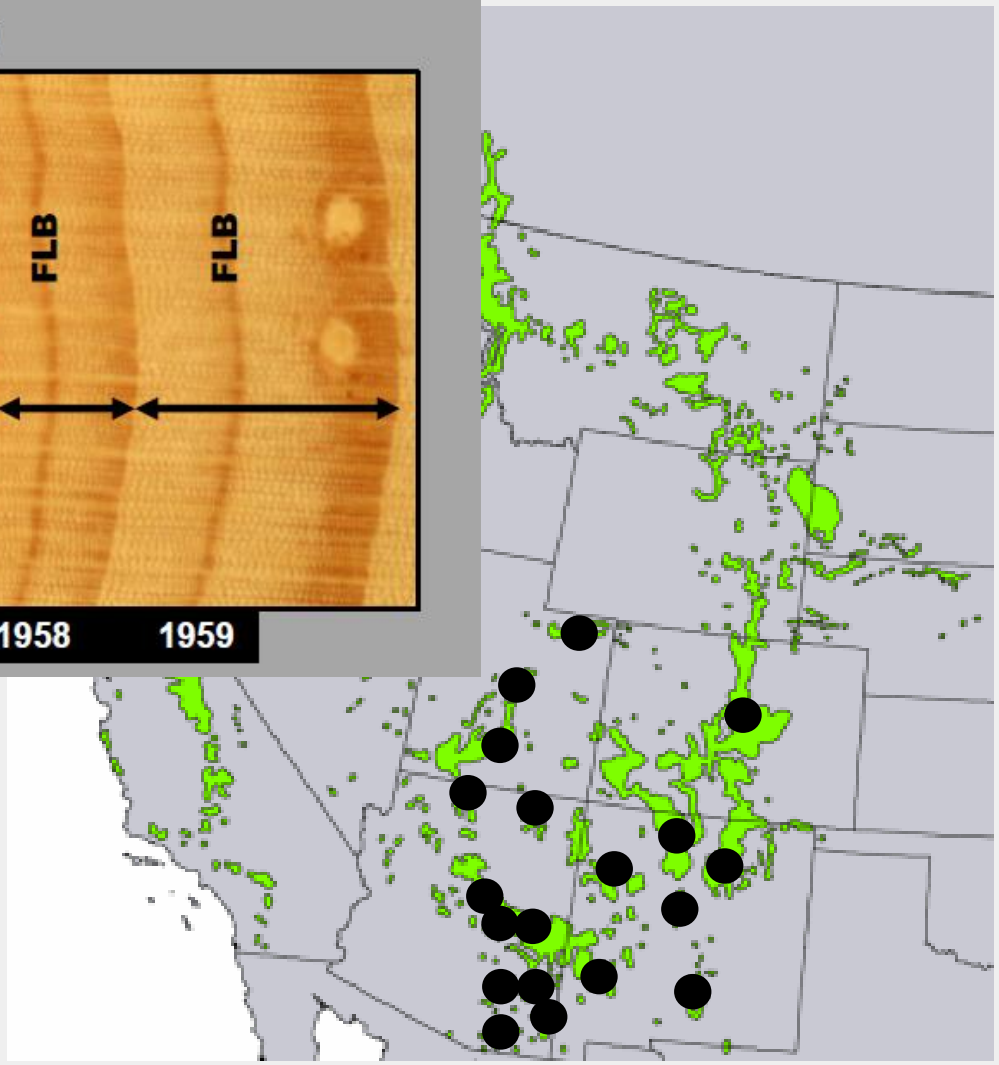
Bringing climate/weather modeling to a smaller scale for rain event prediction and with good land-atmosphere coupling

Integrating ecology models and watershed scale hydrology models with climate-weather modeling to explore local ecological processes.

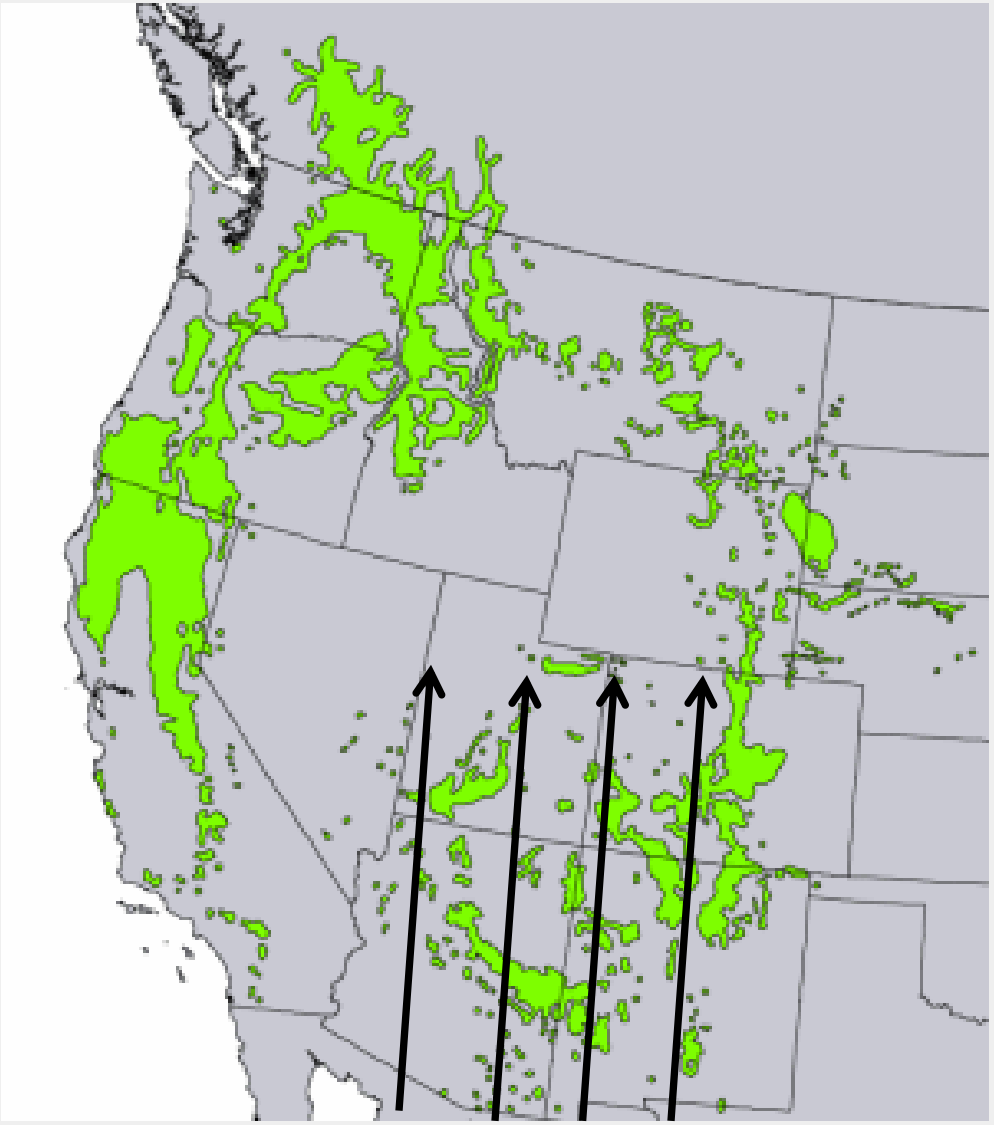


With the climate/weather modeling in hand we hope to make predictions of interannual and spatial variance in the amount of NAMS precipitation and validate with tree ring data





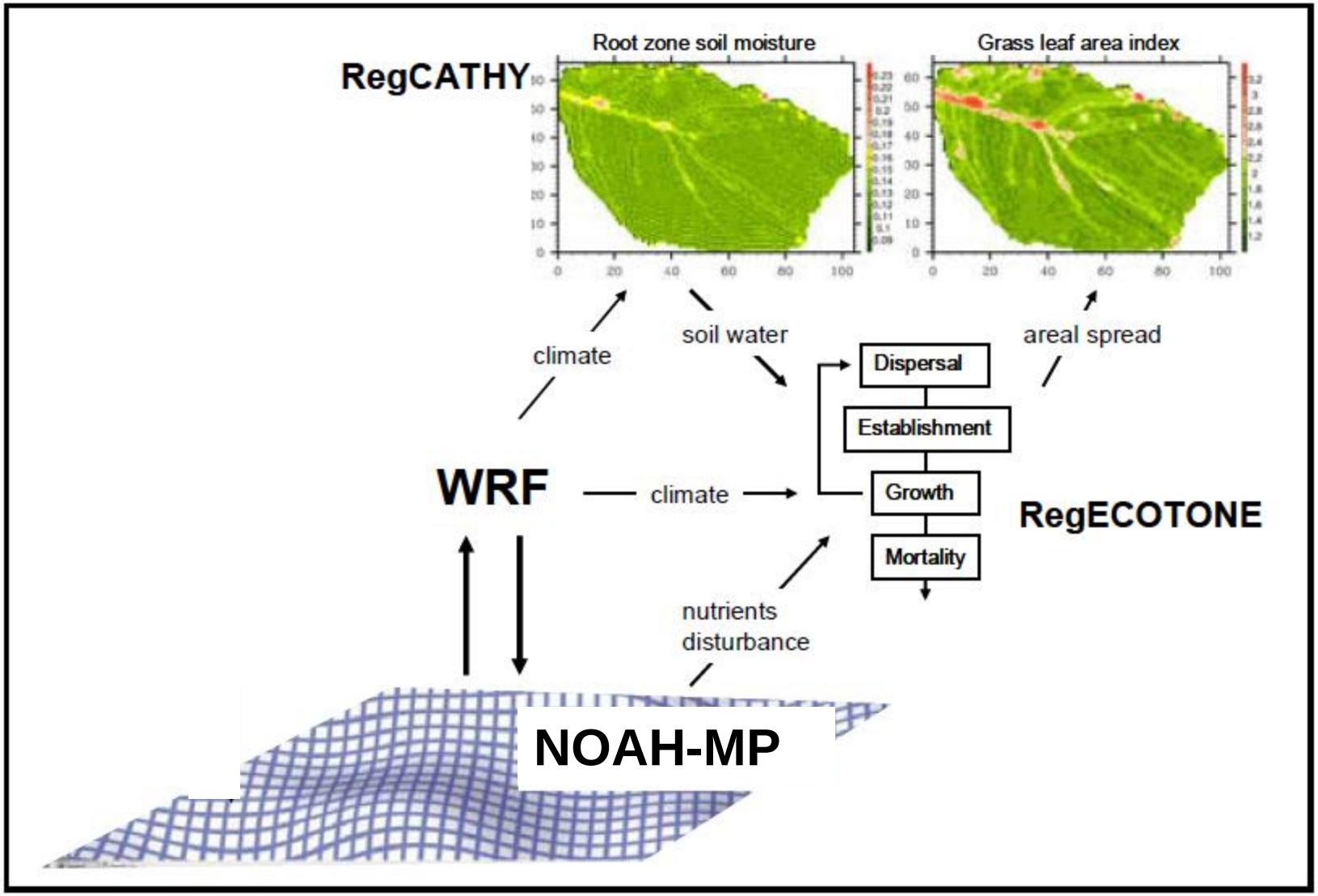
Defining NAMS Macrosystem boundaries through transition in use of winter versus summer precipitation



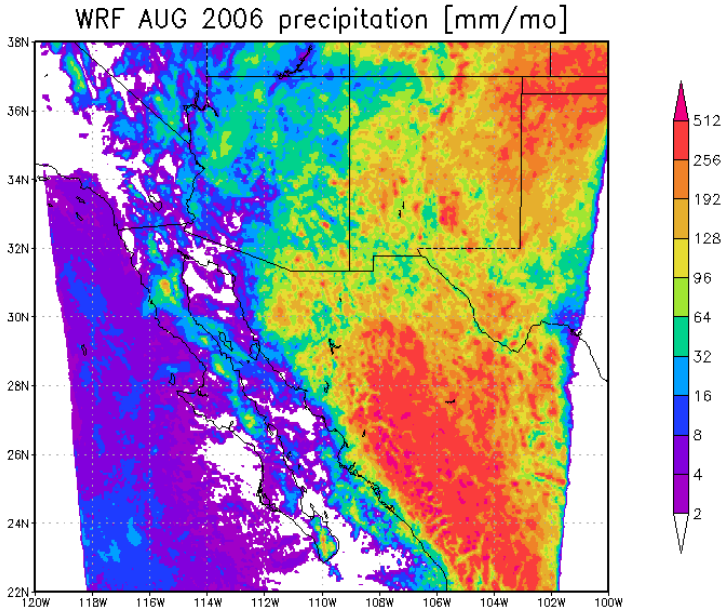
Distribution of *Pinus ponderosa* (broadly defined)

The search for northerly and westerly shifts in the O isotope ratio of late-wood cellulose

Studying the potential for summer-active invasive grasses to expand across designated watersheds within the NAMS domain, as affected by regional climate-surface interactions

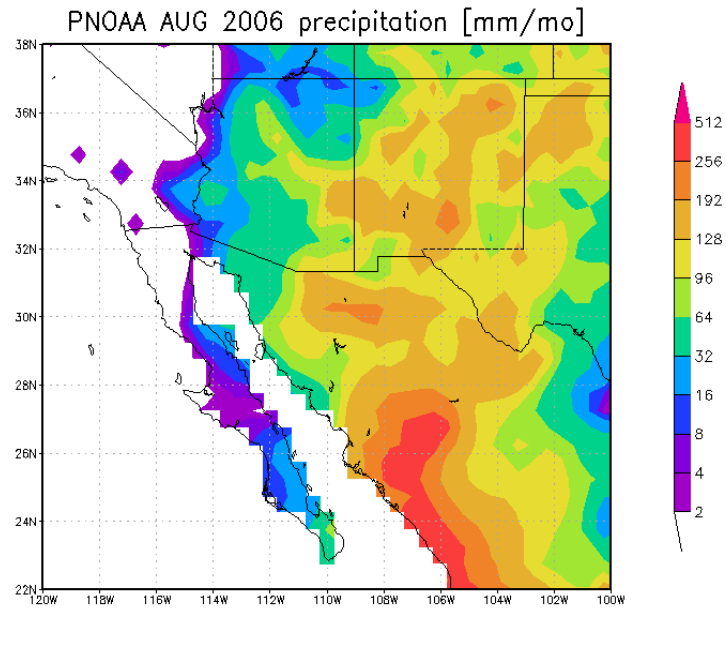


5 km resolution

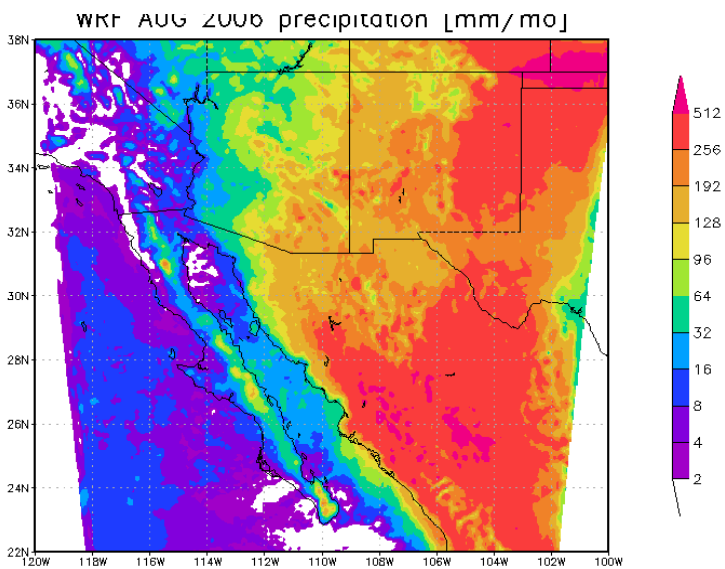


evaluation of model-data error

Observations

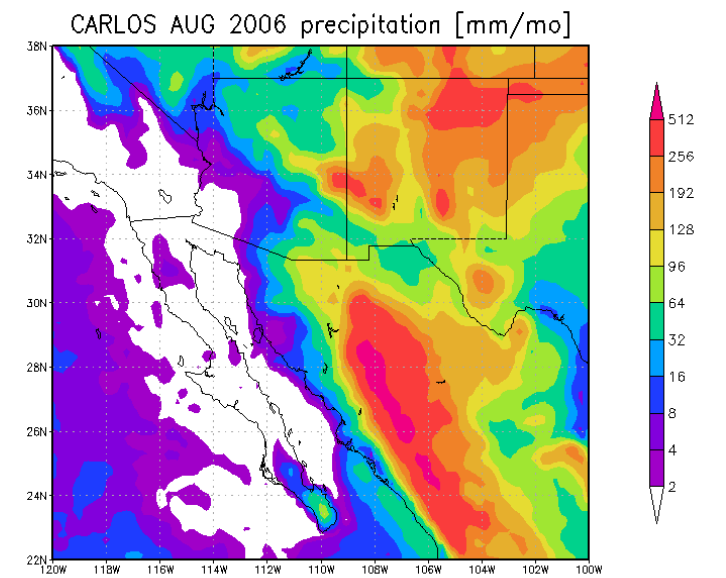


dismiss the convective parameterization



10 km resolution

set boundary condition

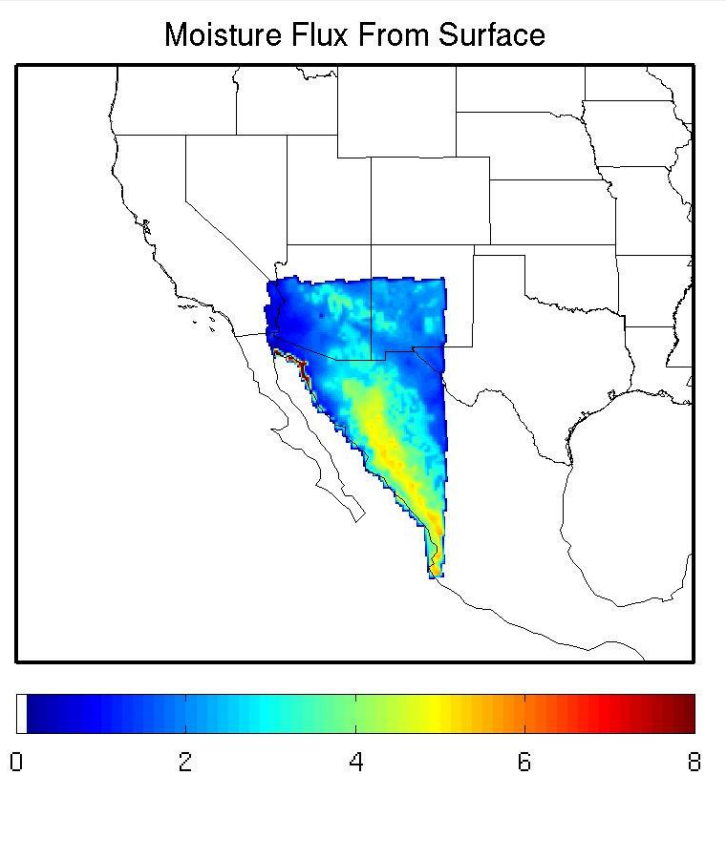


35 km resolution

Water vapor tracer modeling to define NAMS

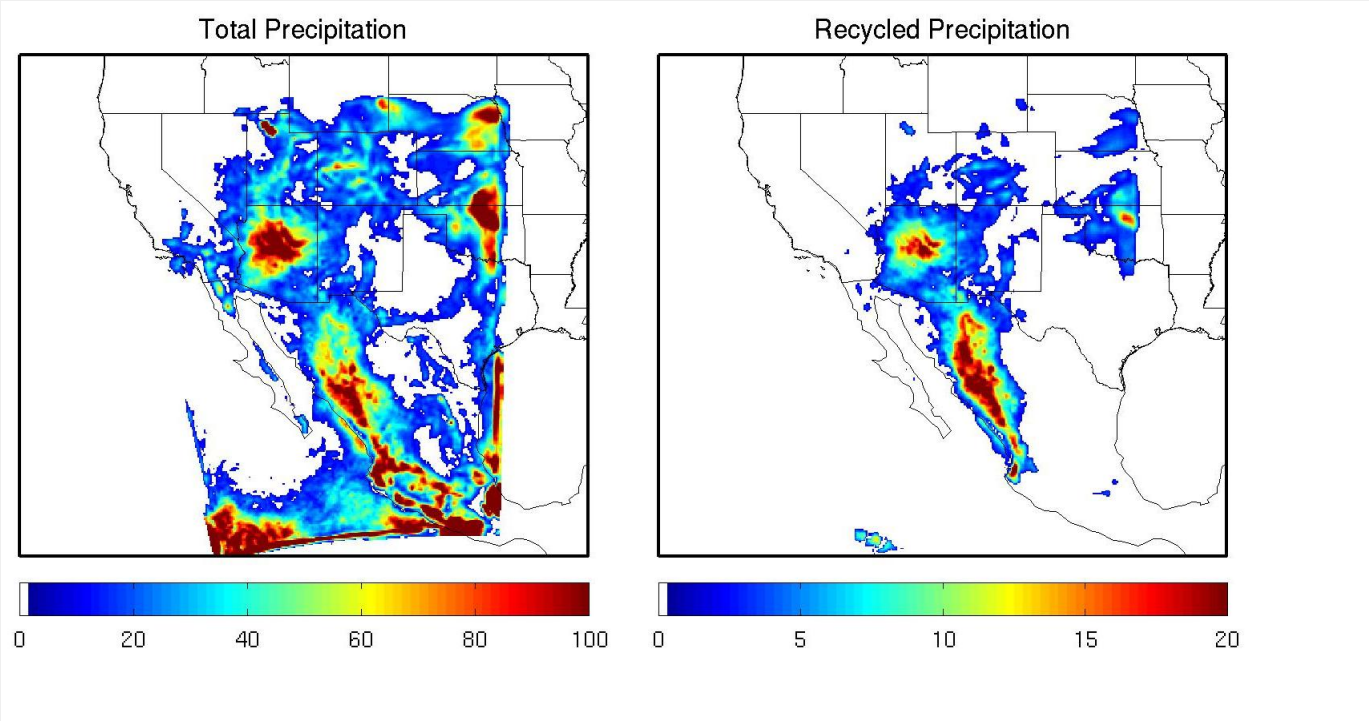
Water vapor tracers are embedded into the WRF regional climate model

Tracers are launched from the core monsoon region at the rate of surface evapotranspiration, and followed until they leave the atmosphere as precipitation.



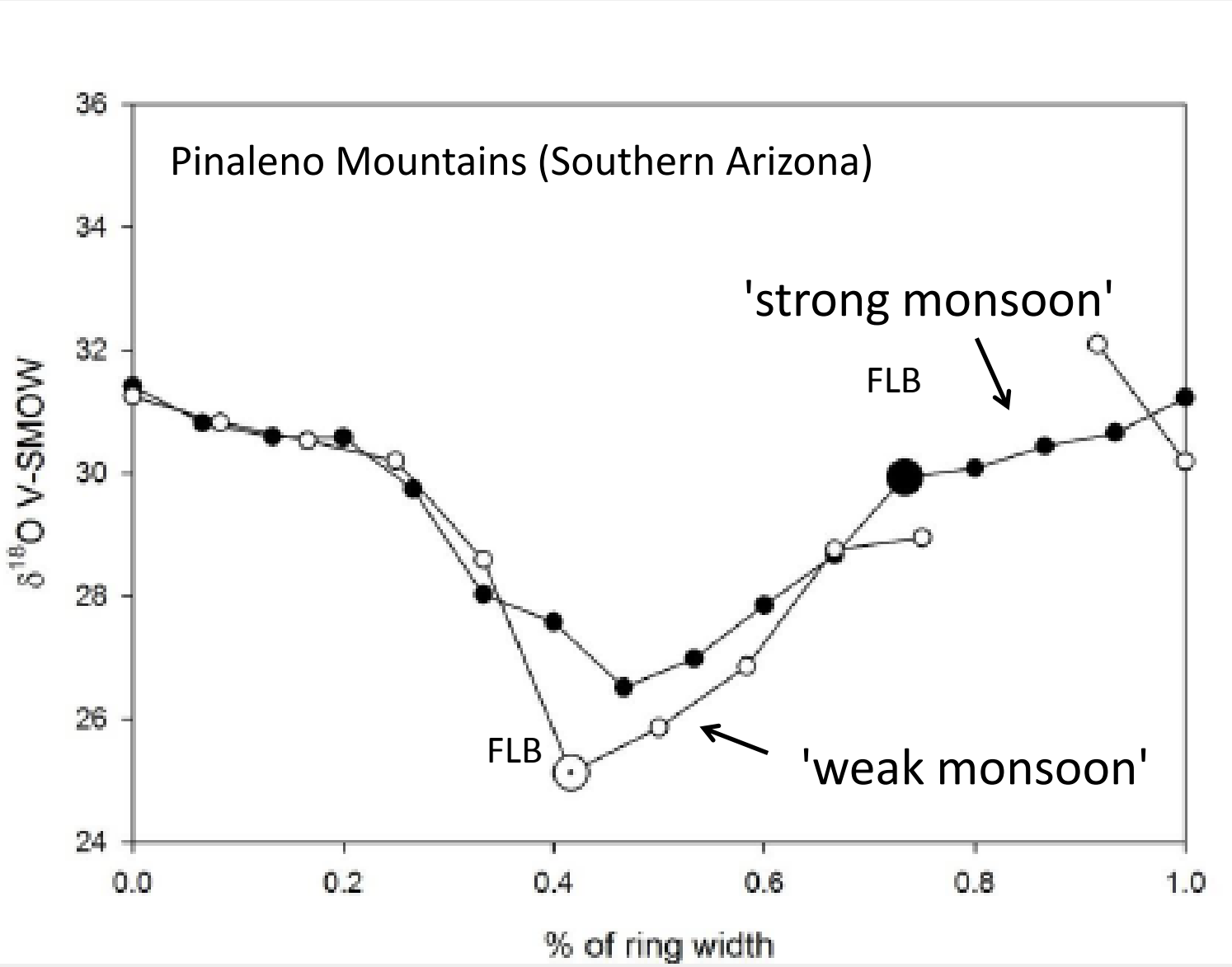
Time mean evapotranspiration Aug-Sep 2006 (mm/day)

Using water vapor tracers we can evaluate the amount of precipitation that originates as evapotranspiration from the core monsoon region.



Total Precipitation (mm), Precipitation originating as evapotranspiration from the NAM region and recycled for the period September 7 through September 13, 2006

Working with tree rings to decipher the timing and amount of monsoon precipitation…



summer rain

winter rain

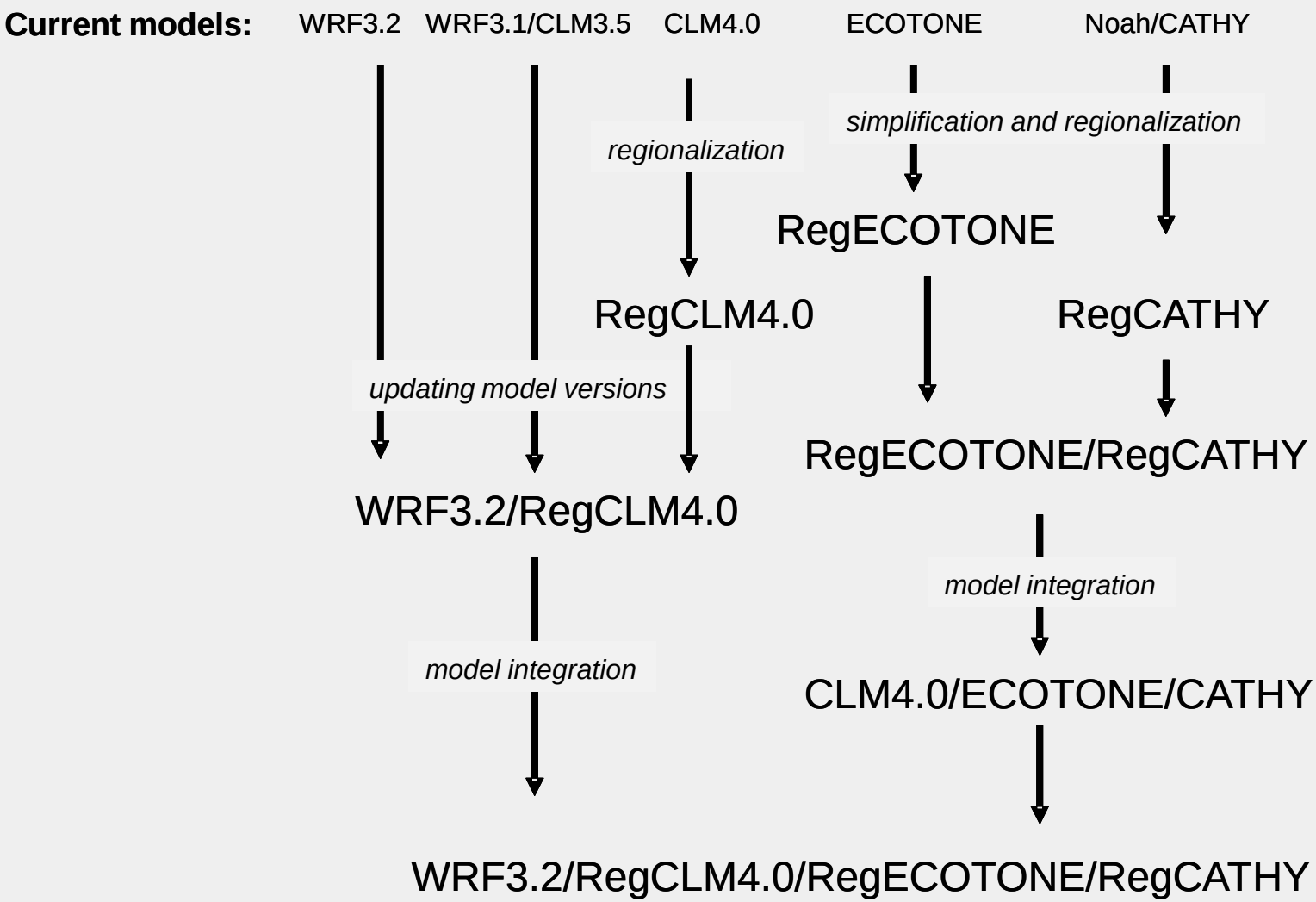
Concluding comments:

Discovery of vegetation-atmosphere processes that are driven by and contribute to the propagation of a primary***, organized*** control on ***regional*** productivity and ecological processes – ***the so-called 'macrosystem'***

The macrosystem concept has the potential to explain regional connectivity among ecosystems and synchronization of ecological phenomena, such as fire cycles and invasive waves by exotic species

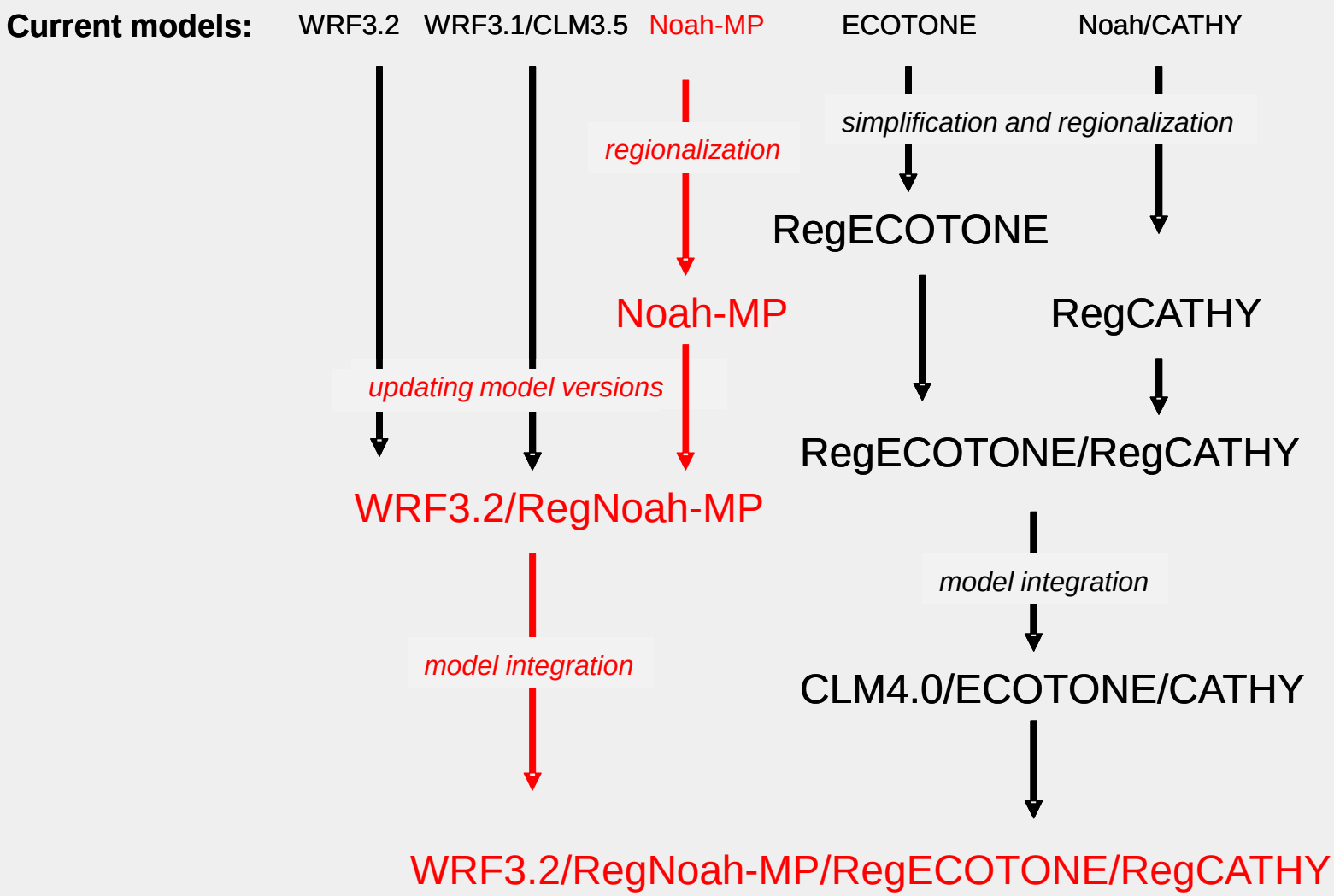
The key to this project is to get the atmospheric scientists, hydrologists and ecologists talking to one another.

Designing Models Capable of Resolution at the Macrosystem Scale

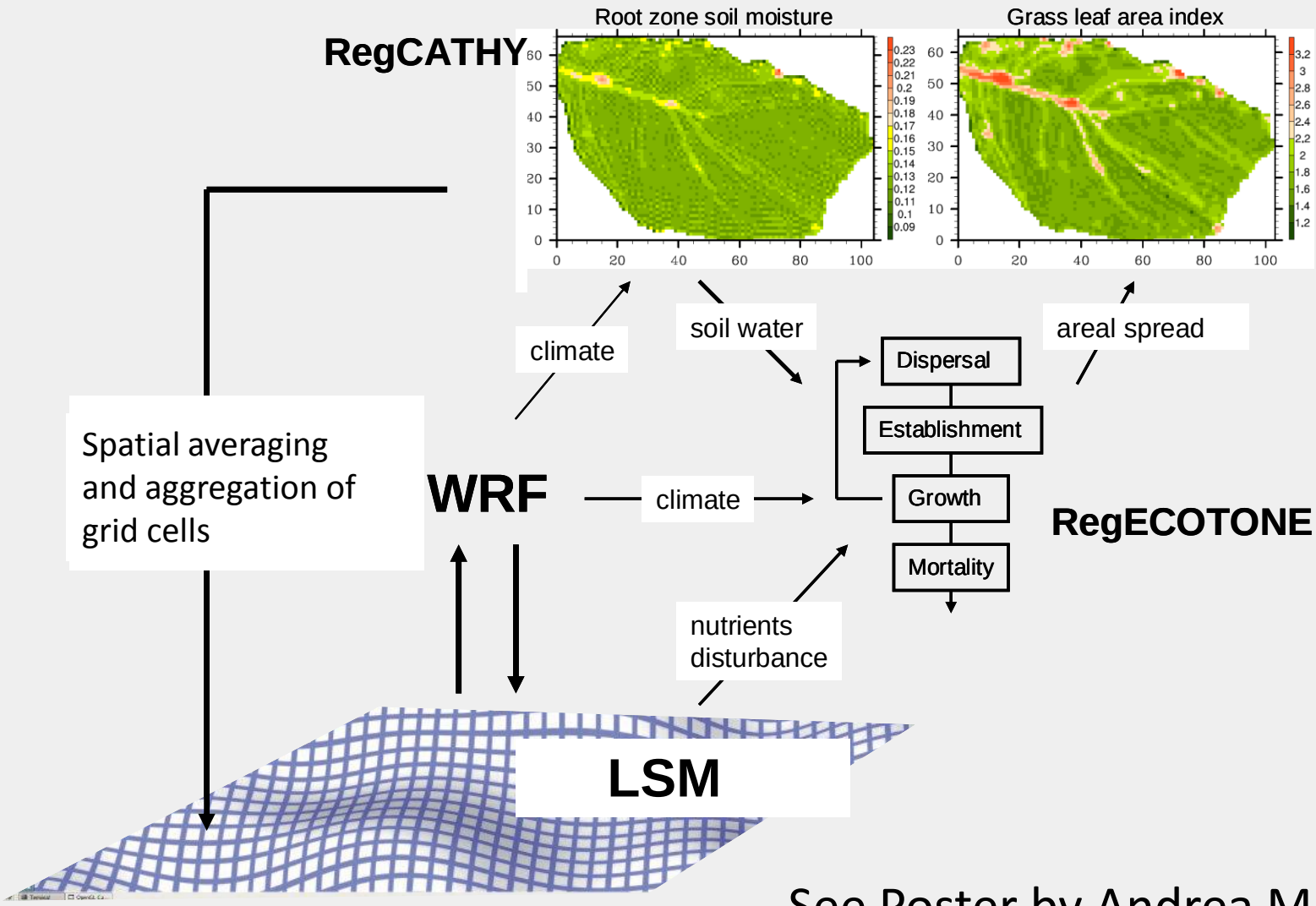


Designing Models Capable of Resolution at the Macrosystem Scale

Revision of LSM of Choice



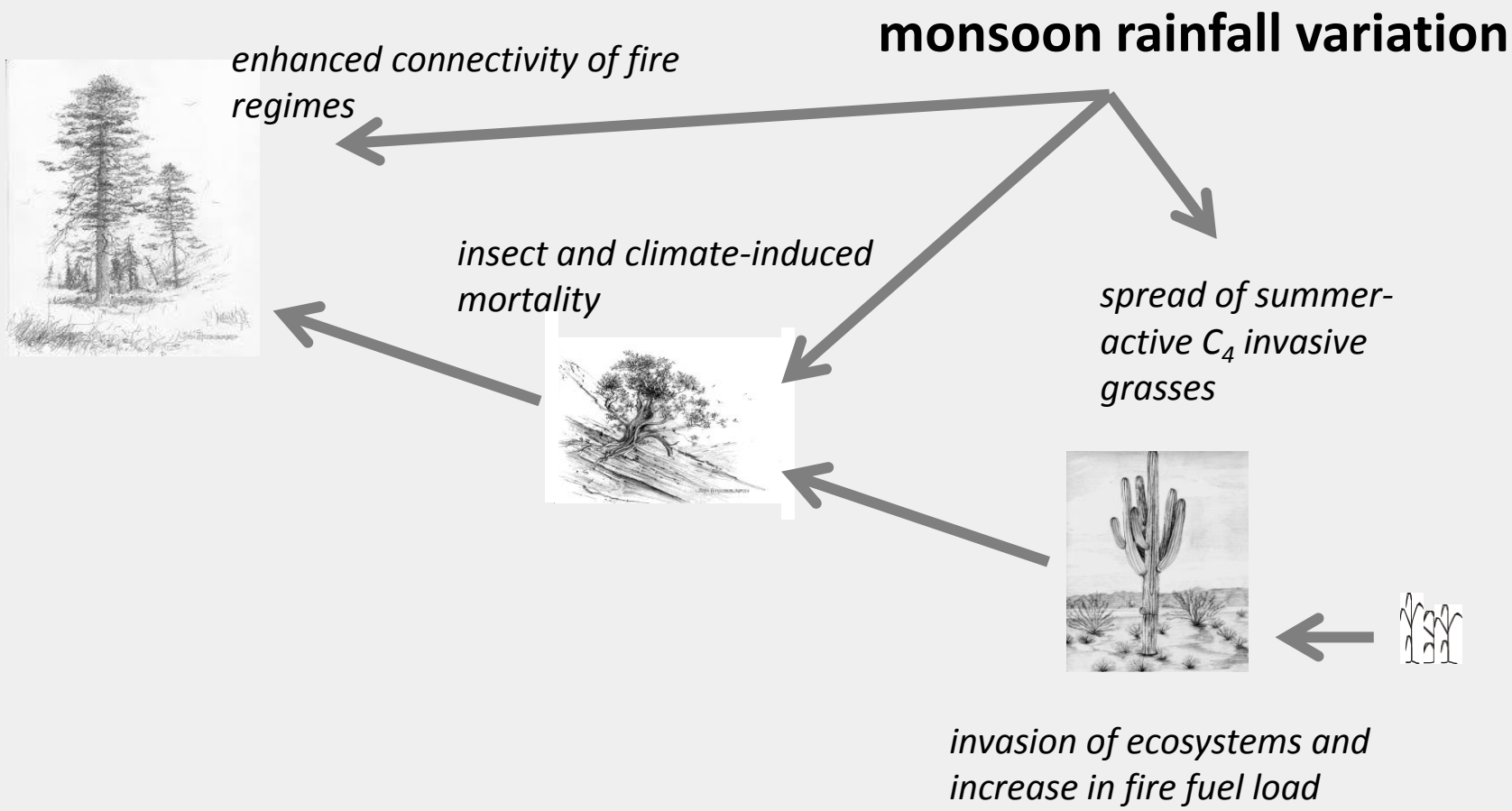
Putting Landscape-Scale Processes Together to Produce Macrosystem-Scale Processes



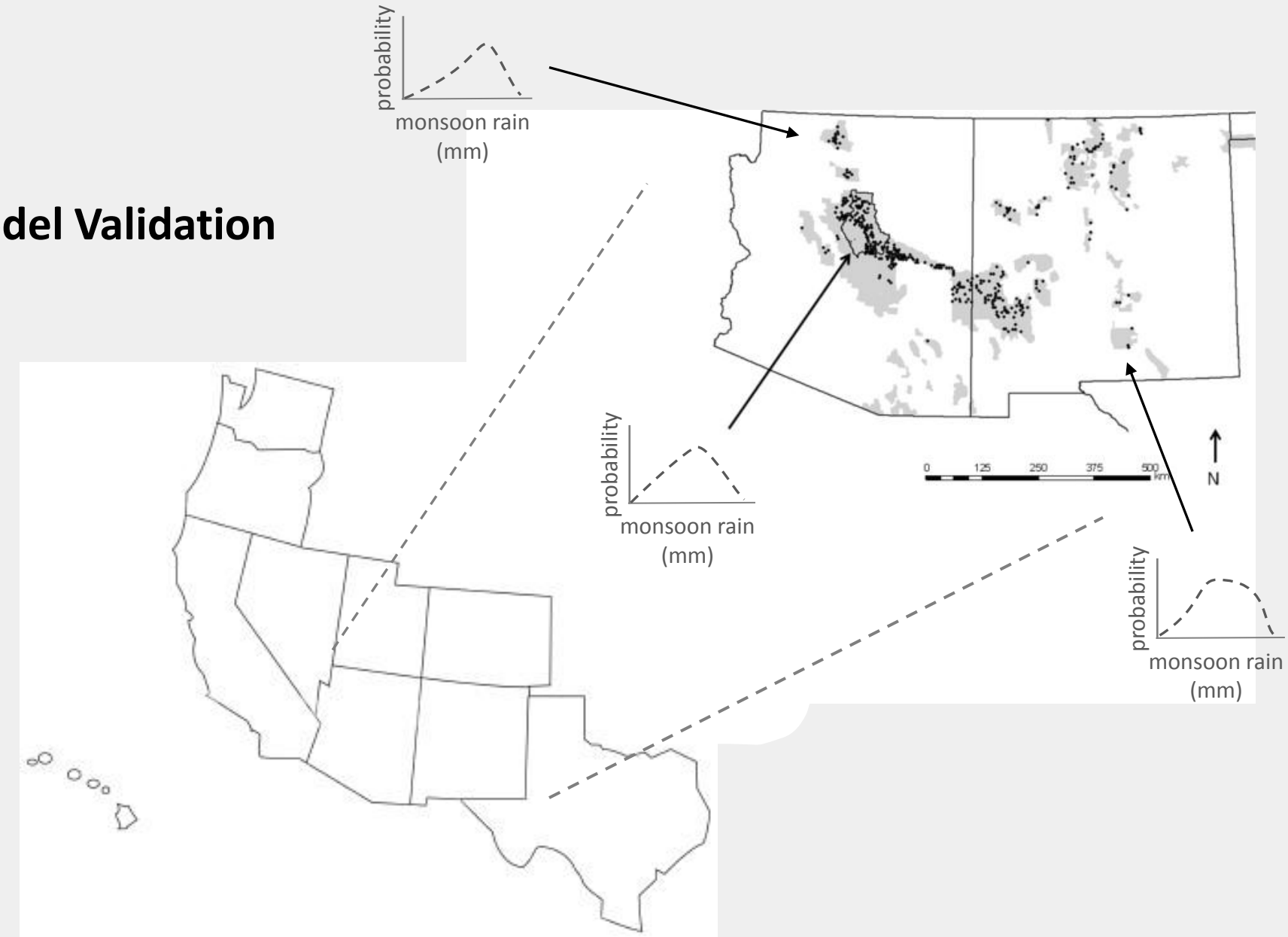
See Poster by Andrea Mathias

The Issues We Want to Pursue … Ultimately

Connectivity and Synchronization among Ecosystems within the Macrosystem Controls by *High-Frequency Variation* in a Regional Climate Driver

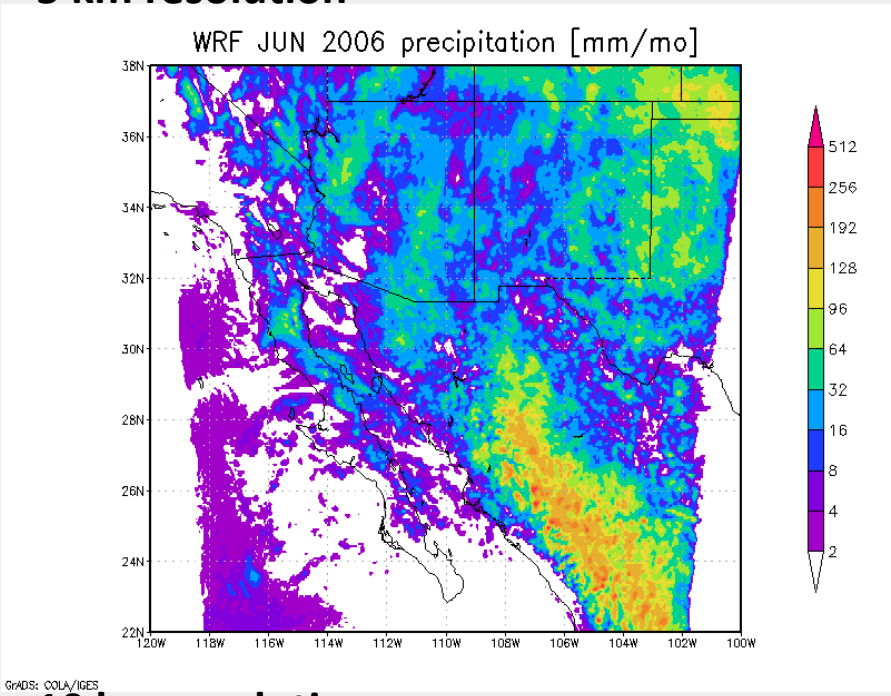


Model Validation

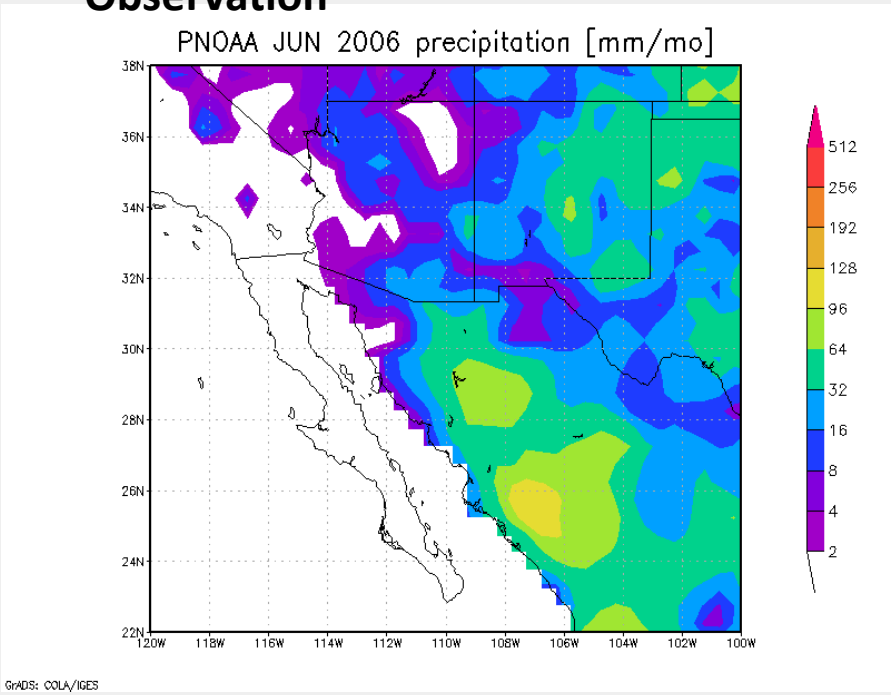


Distribution of Ponderosa pine in Arizona and New Mexico

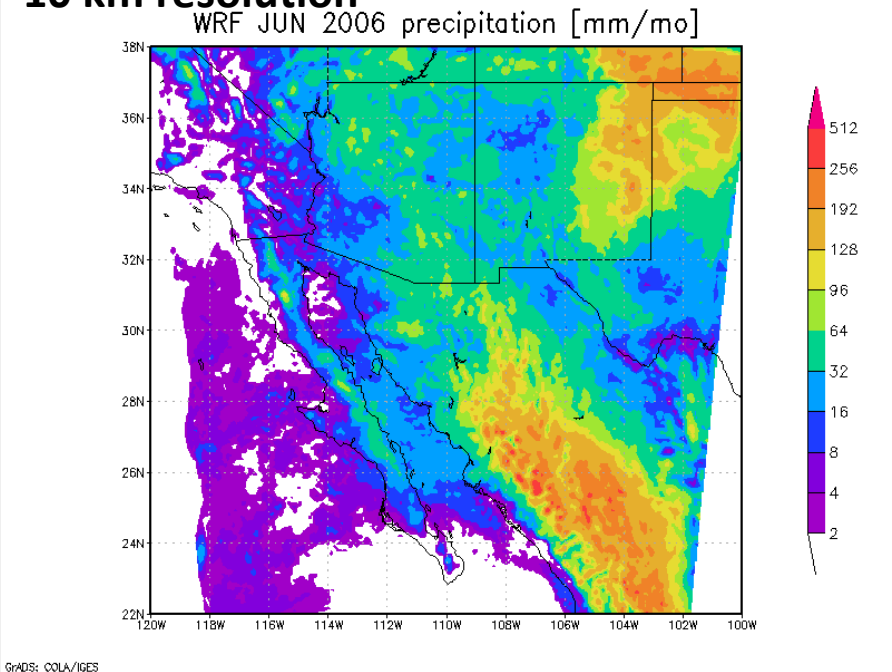
5 km resolution



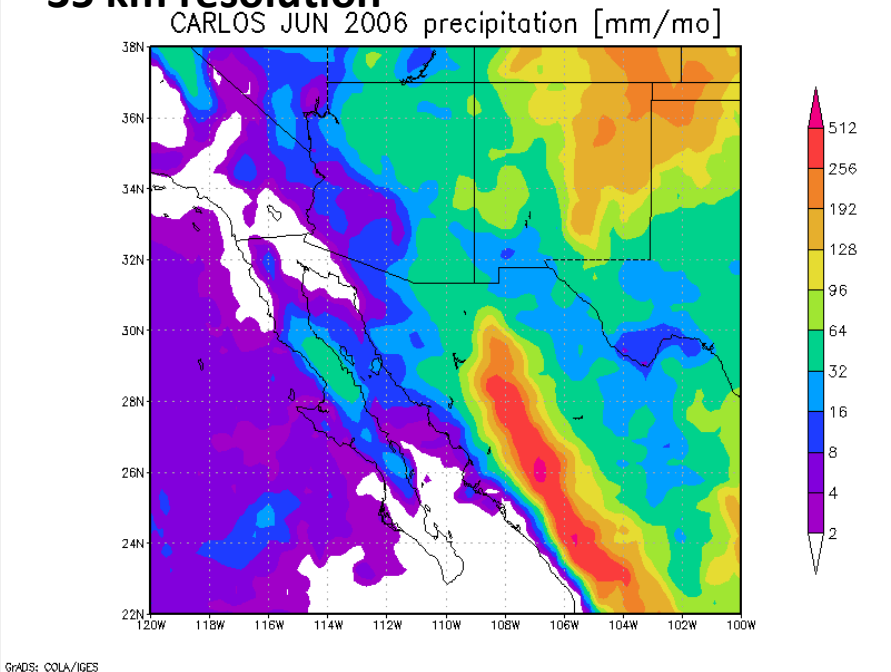
Observation



10 km resolution



35 km resolution



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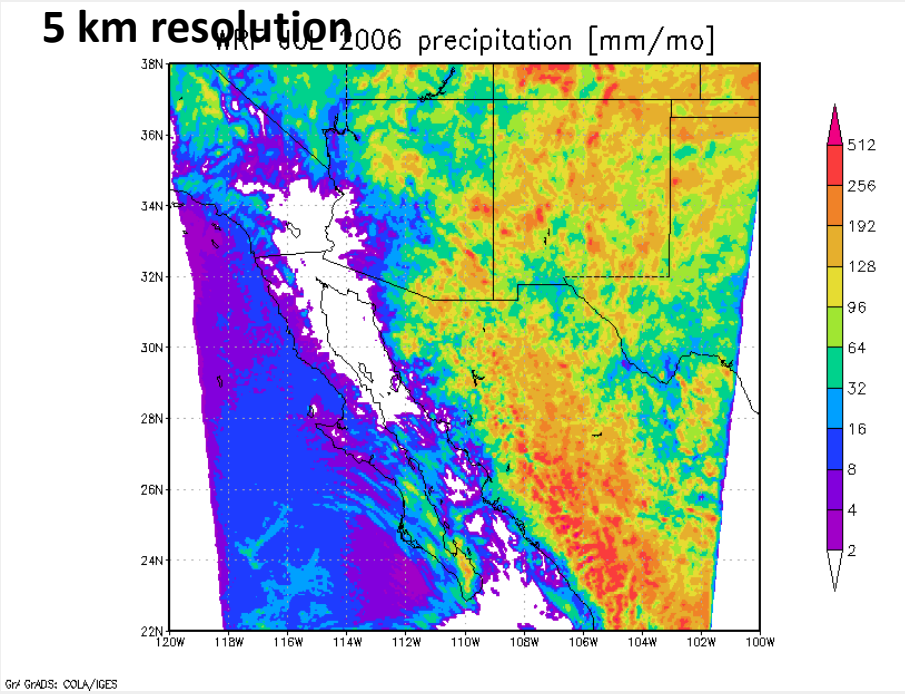
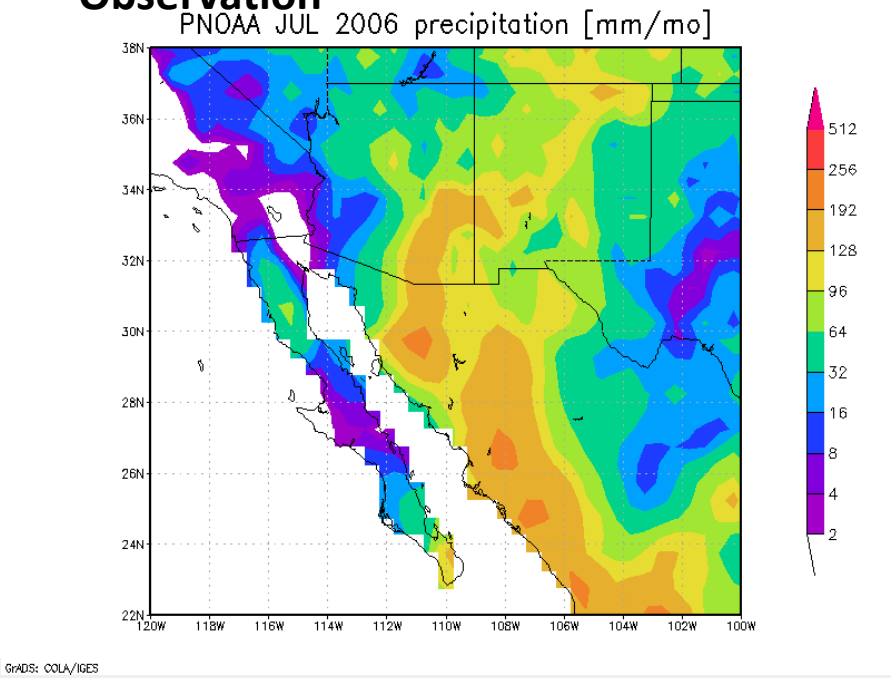
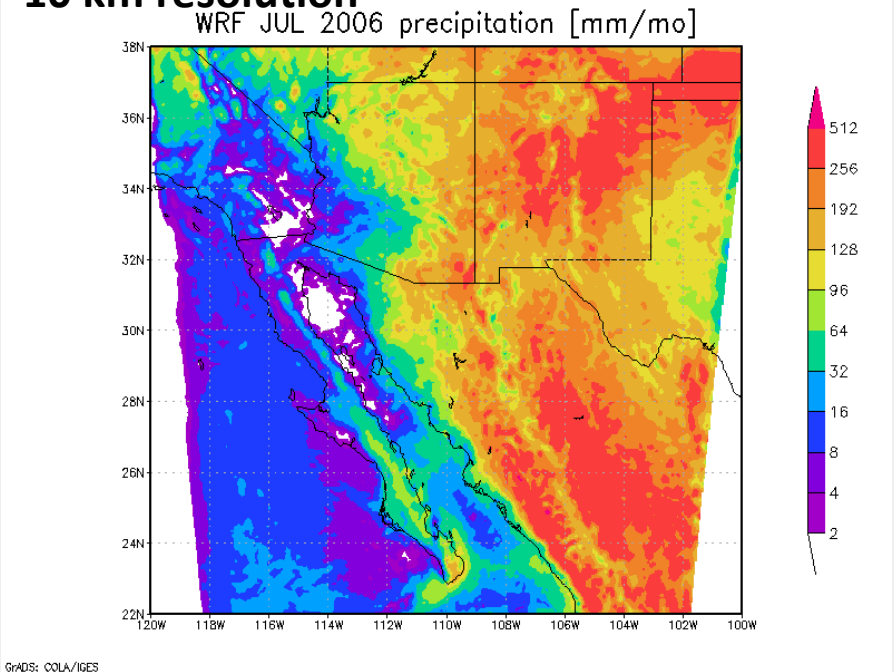


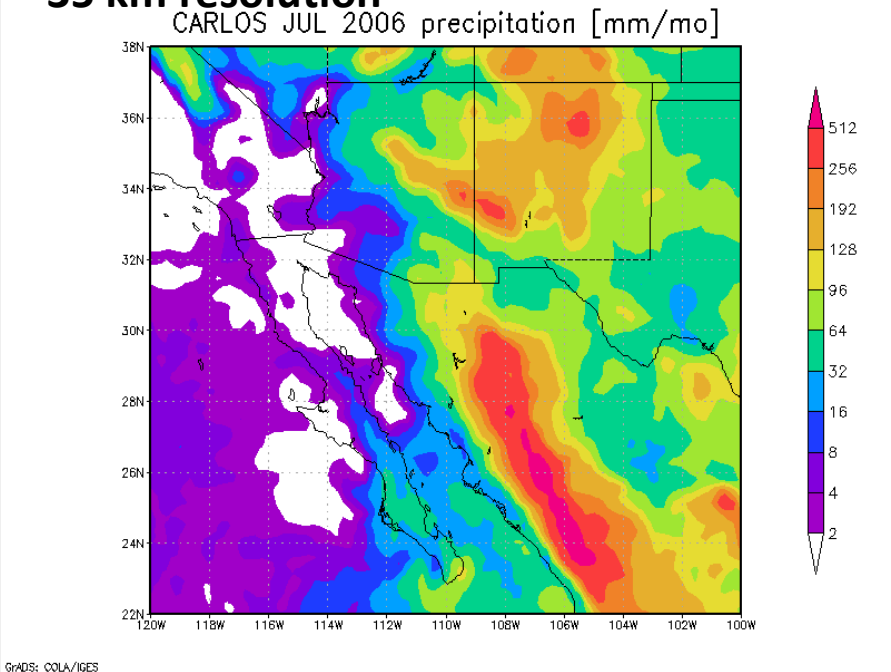
Observation



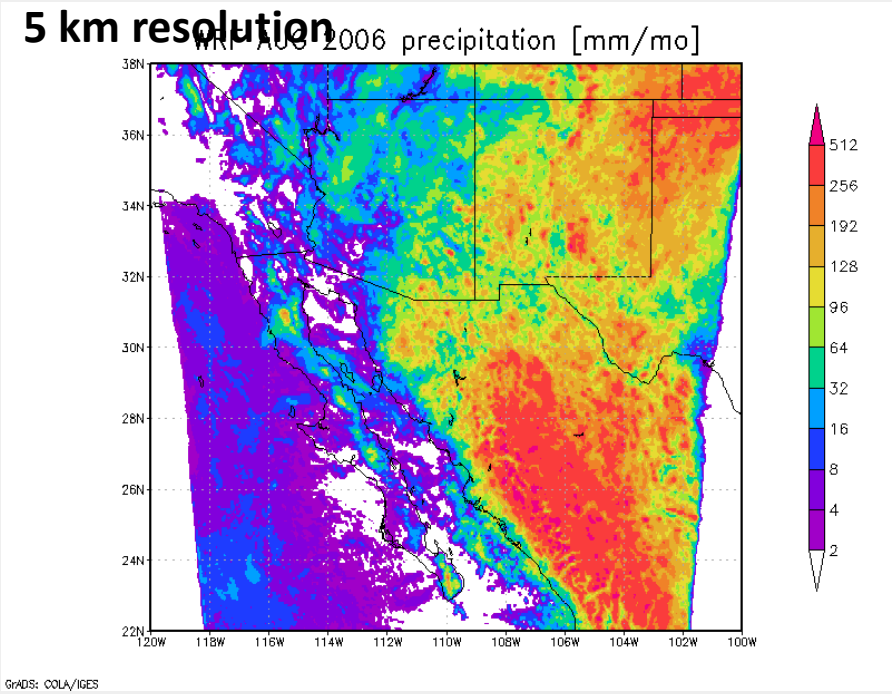
10 km resolution



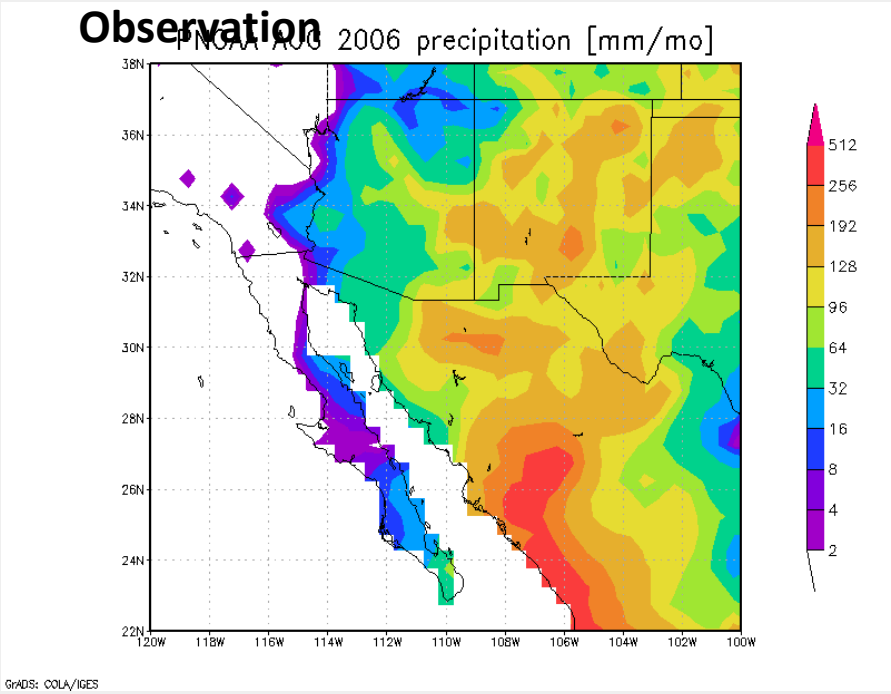
35 km resolution



5 km resolution



Observation



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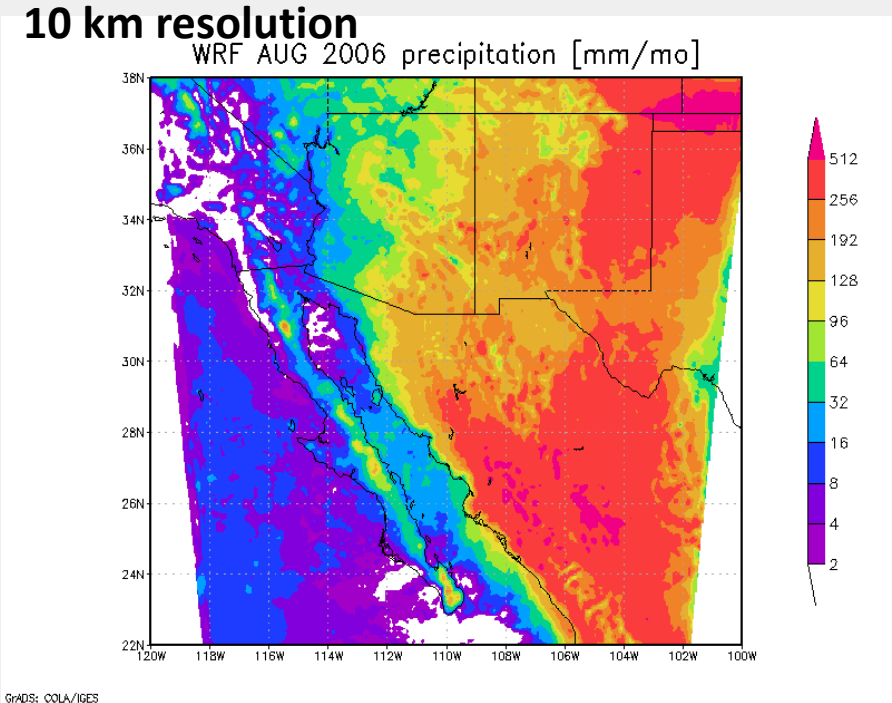

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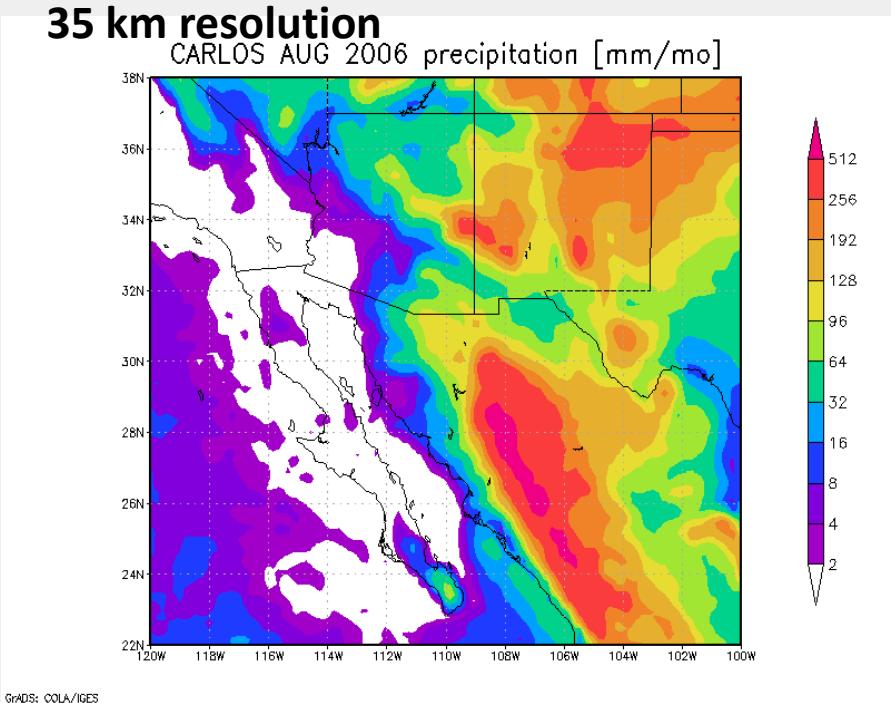
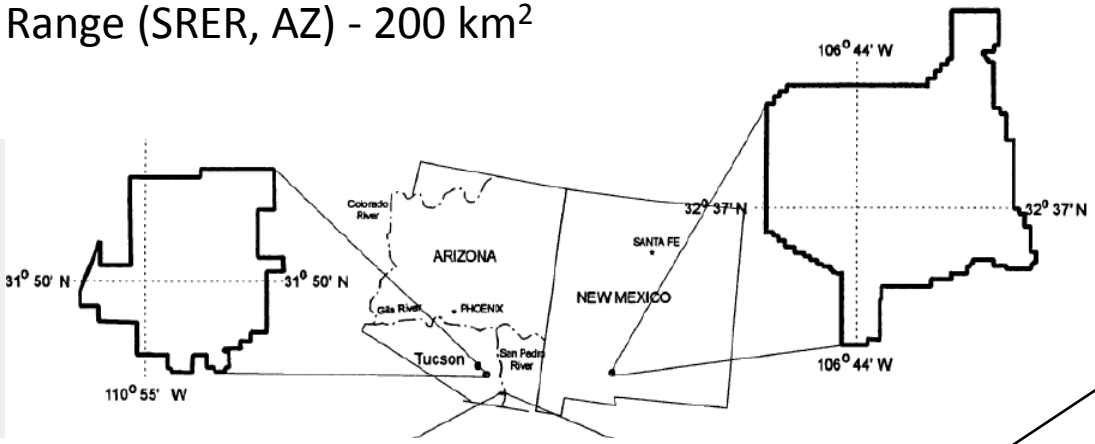


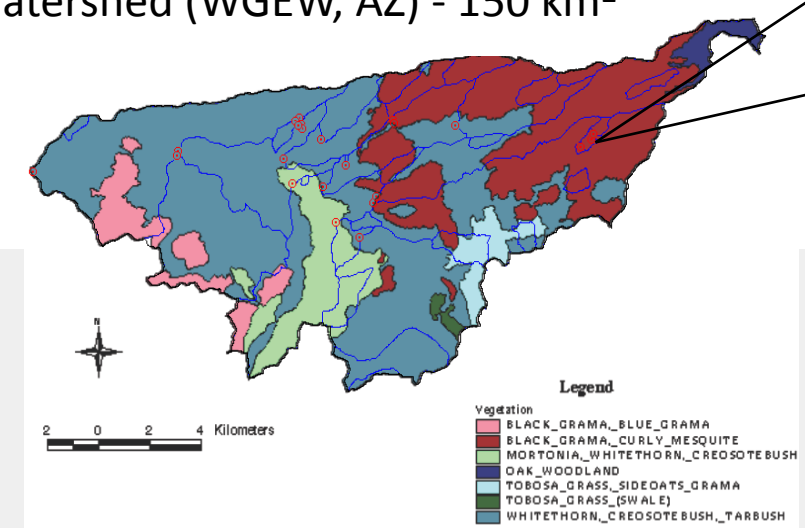
STUDY SITES

Santa Rita Experimental Range (SRER, AZ) - 200 km^2

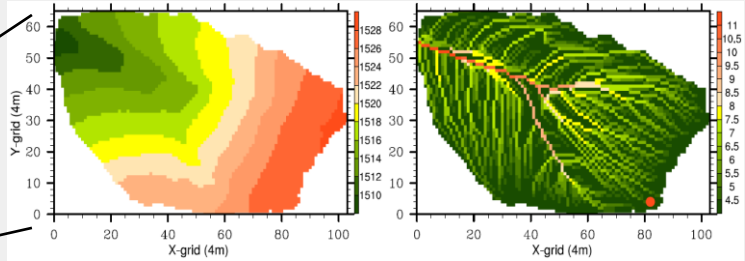
Jornada LTER (NM) - 800 km^2



Walnut Gulch Experimental Watershed (WGEW, AZ) - 150 km^2



Kendall catchment

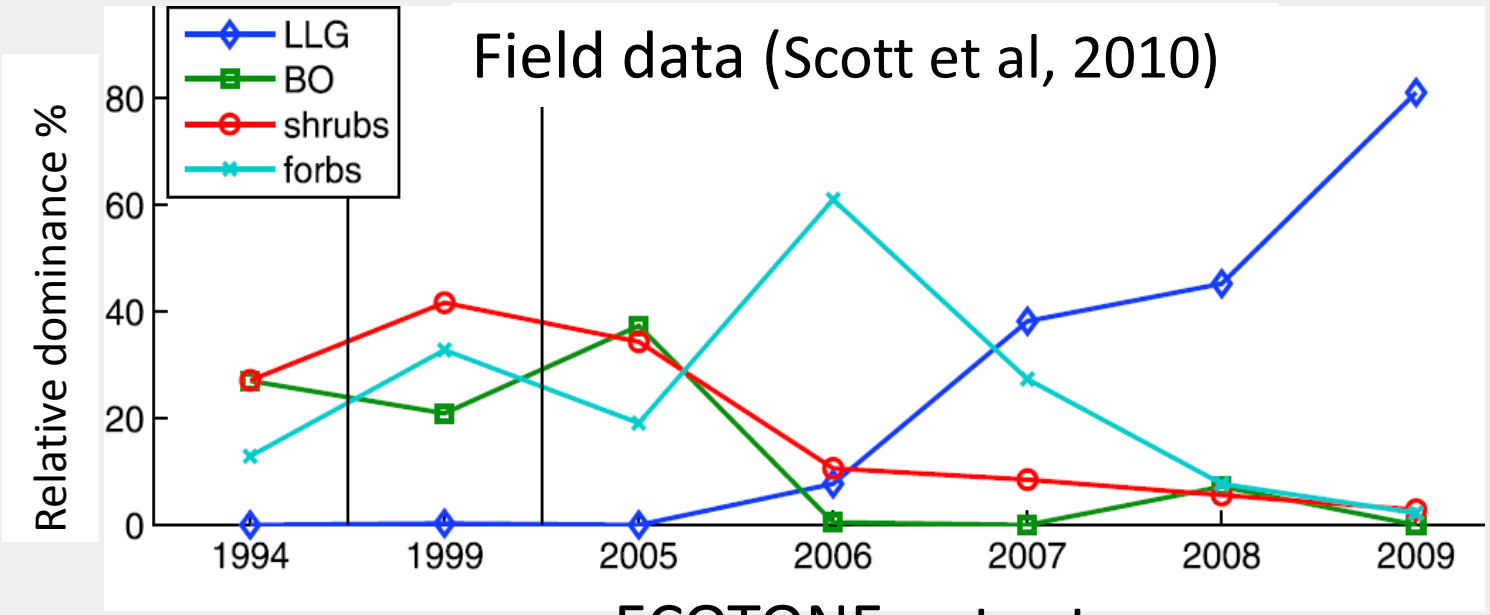


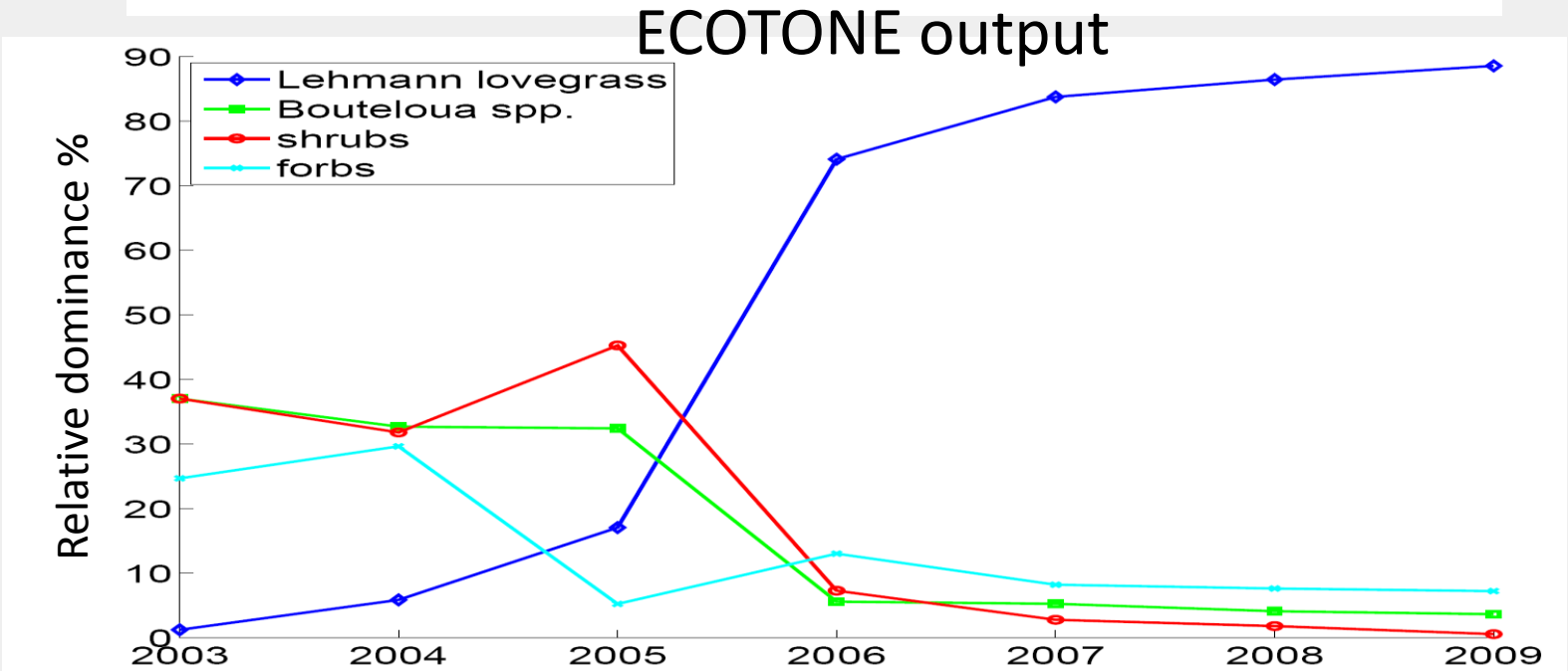
Elevation model (left) and upstream area (right) at 4 m resolution (Niu et al, 2013, Ecohydrology)

KENDALL SITE

- Spread of the invasive Lehmann lovegrass (Eragrostis lehmanniana) and decline of native vegetation (Scott et al, 2010)
- Lehmann lovegrass has higher seedling survival and establishment rate in dry years
- Used site characteristics, weather data and species specific paramters to simulate vegetation change
- ECOTONE individual based vegetation model (Peters, 2002)

VEGETATION CHANGE





MODEL COUPLING

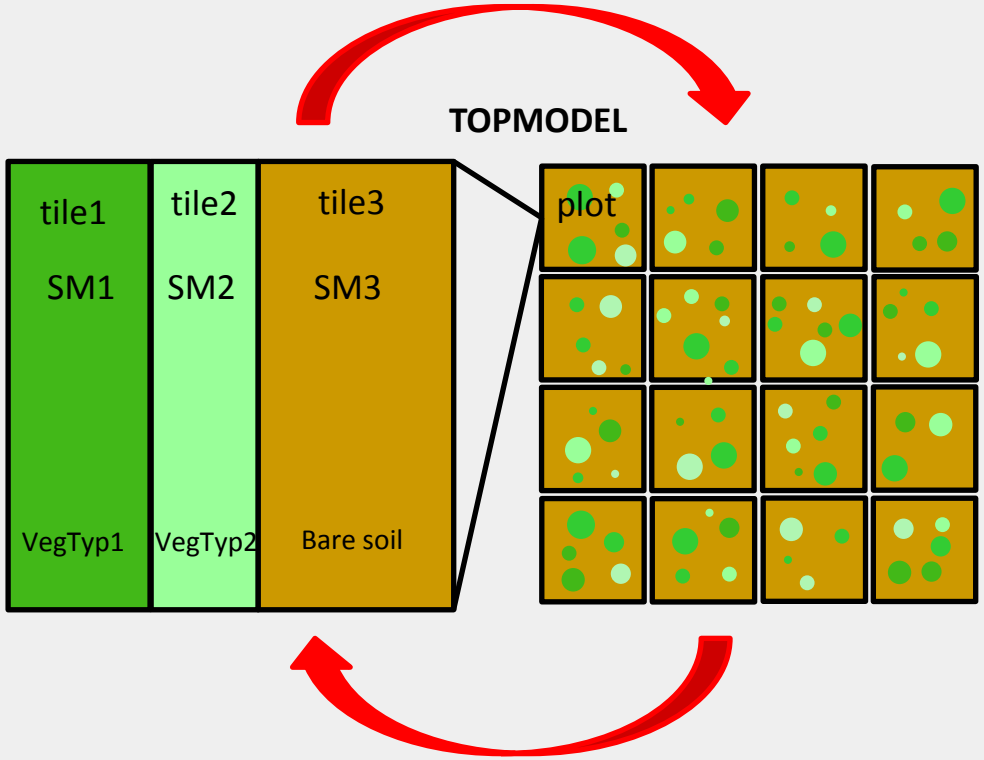
Abiotic environment: available soil moisture
air and soil temperature

NoahMP-CATHY

Structure: Grid cells ($1km^2$) / tiles

Input: vegetation type, soil type, climatic forcing

Output: Surface energy, water and carbon fluxes



ECOTONE

Structure: Landscape / plots ($1\text{-}100m^2$)

Input: soil moisture, temperature, species distribution and parameters, germination and establishment probabilities

Output: biomass and species distribution

Vegetation feedbacks: Biomass, root distribution in soil layers, vegetation fraction and cover, litter, leaf area index