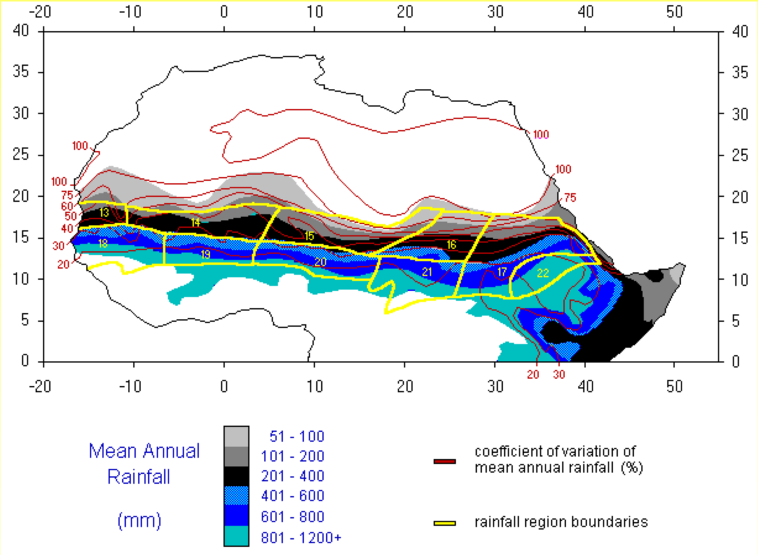
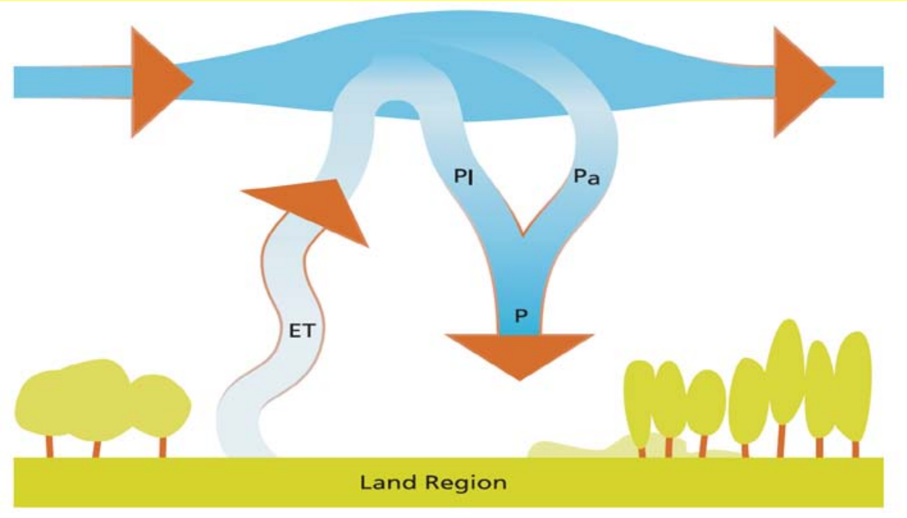
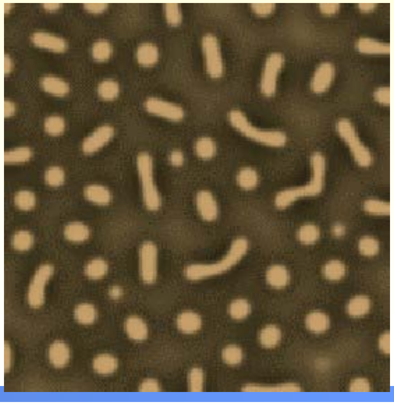
Coupling Veg Pattern to ABL model







Motivation:

- The ABL model predicts a wet or dry atmosphere
- Due to small scale pos FB mechanisms, more LE to atmosphere

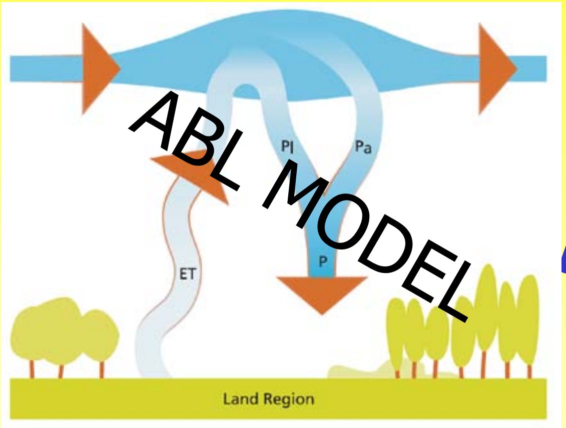
Aim:

Can small scale FB mechanisms shift the atmosphere from dry to wet?

Work in progress:

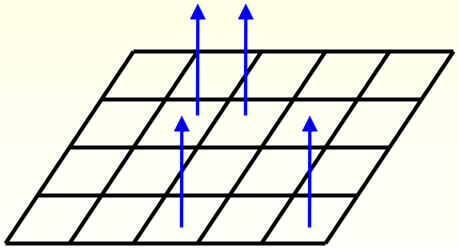
- Including heat flux
- Including albedo dependency on biomass
- Coupling of small scale pattern to ABL model (presentation)
- Including new surface runoff scheme (presentation)

Coupling



$$\frac{\partial O(\vec{x},t)}{\partial t} = [rainfall] - [infiltration] \pm [overland\ flow]$$

$\overline{\mathrm{ET}}$

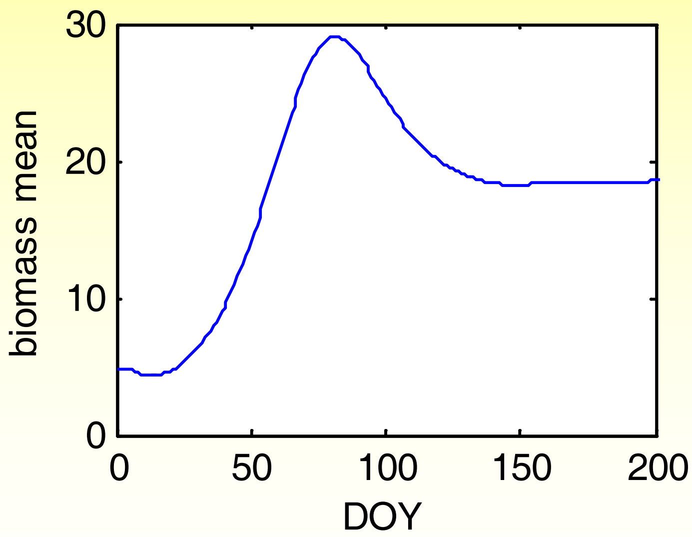


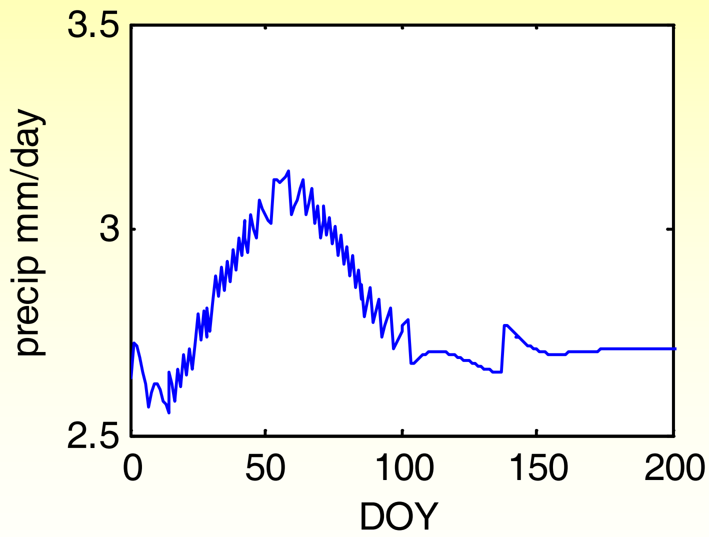
Trans+Evap

$$\frac{\partial W(\vec{x},t)}{\partial t} = [infiltration] - [uptake] - [evaporation] \pm [water\ movement]$$

Results coupling

- Include PM equation, energy balance
- Problems with units, dimensions, space/time discretizations
- With US data for input in the ABL:
  Too much precip from atmosphere
  - Arid model becomes forest without patterns
  - But more or less stable





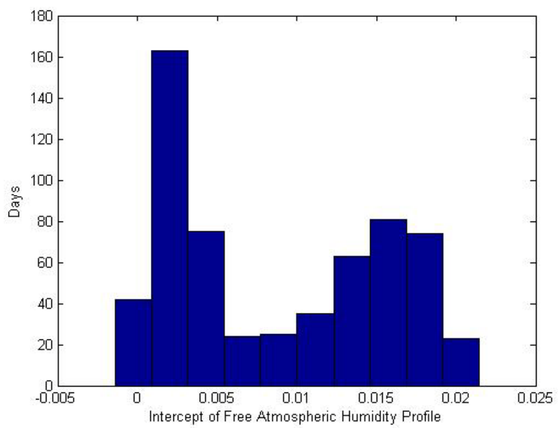
Free atmosphere description

Get atmospheric profile for the area along 2 years

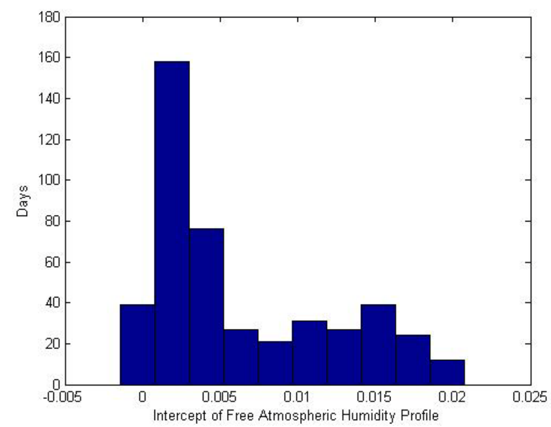
$$q = m/(1+m)$$

Potential Temperature

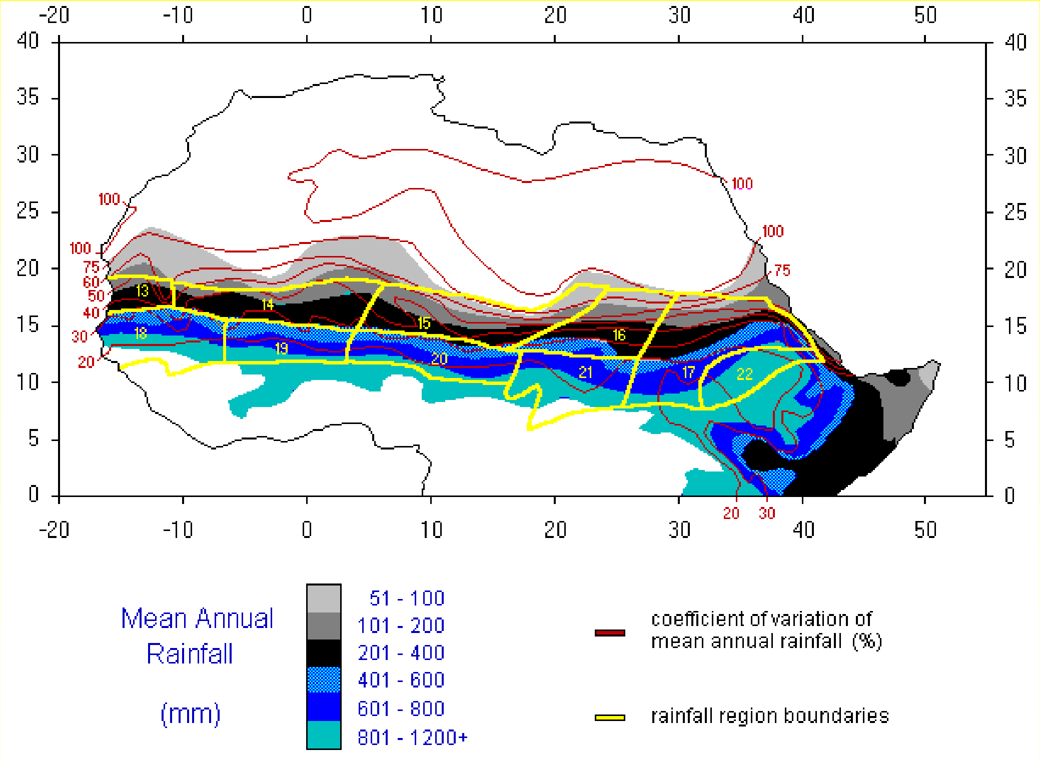
Regression on the data



Cut monsoon season

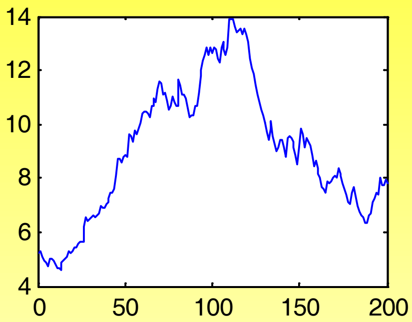


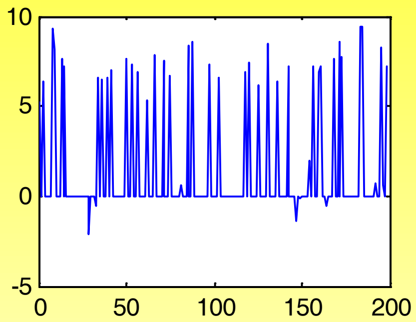
Take data from this distribution each day

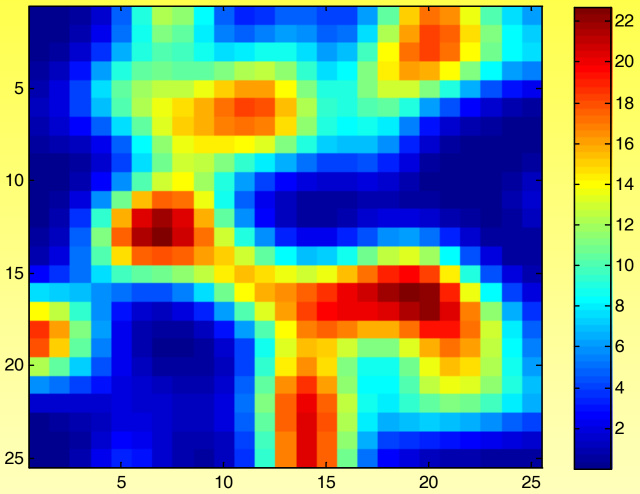


Mean Annual Rainfall (mm)
51 - 100
101 - 200
201 - 400
401 - 600
601 - 800
801 - 1200+
coefficient of variation of mean annual rainfall (%)
rainfall region boundaries

With good data







1. Average precip is 1.3 mm/day … reasonable
2. There is a pattern!
3. More tuning on atmosphere (longer dry periods)+more tuning on pattern

Basic model for patterned vegetation

$$\frac{\partial P}{\partial t} = Growth(P,W) - Mortality(P) \quad + D_P \Delta P$$

$$\frac{\partial W}{\partial t} = Infiltration(O,P) - Uptake(P,W) - Loss(W) + D_W \Delta W$$

$$\frac{\partial O}{\partial t} = Rain - Infiltration(O,P) + \boxed{D_O \Delta O}$$

Revised Overland Flow Model

- Open Chanel Flow:

$$V_x = \frac{1}{n} O^{2/3} \left(S \right)^{1/2}$$

$$V_x \approx \frac{1}{n} O^{2/3} \left(\left| \frac{\partial O}{\partial x} \right| \right)^{\alpha} \operatorname{sgn}\left(\frac{\partial O}{\partial x} \right);$$

$$q_x = V_x \times O$$

$$n = f(P)$$

Revised Model

$$q_x = -D_o(O, P) \left(\left| \frac{\partial O}{\partial x} \right| \right)^{\alpha} \operatorname{sgn}\left(\frac{\partial O}{\partial x} \right)$$

Revised Overland Flow Model

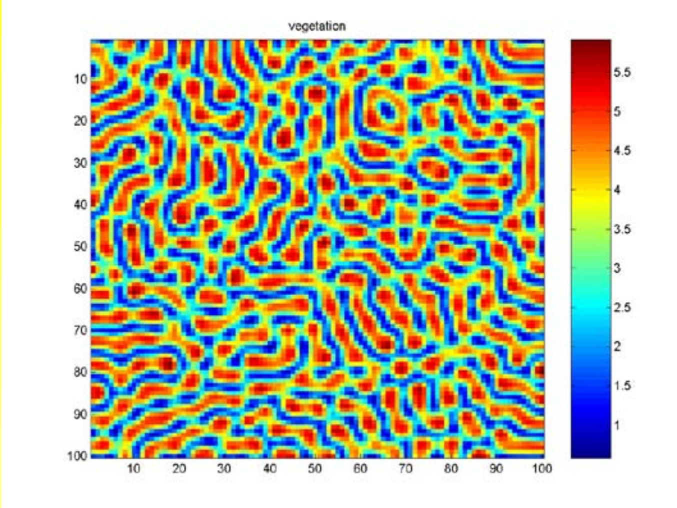
- Question to be addressed: What happens to the vegetation pattern for the following cases:

$$\alpha = 1$$

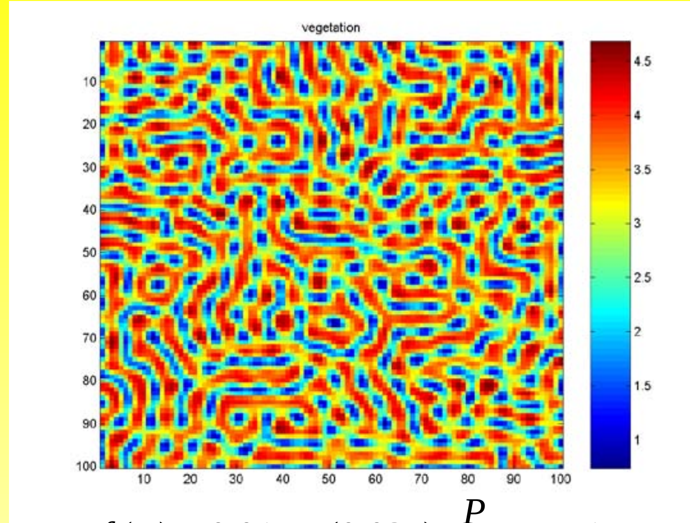
$$\alpha = 0.5$$

$$f(P) = 0.015$$

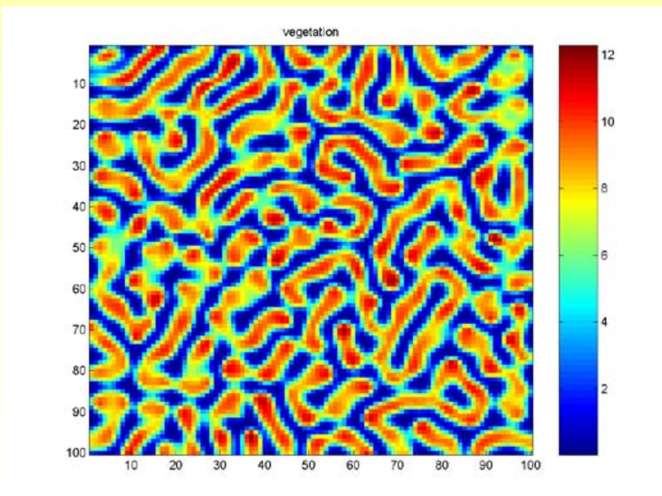
$$f(P) = 0.015 + (0.035)\frac{P}{P_{max}}$$



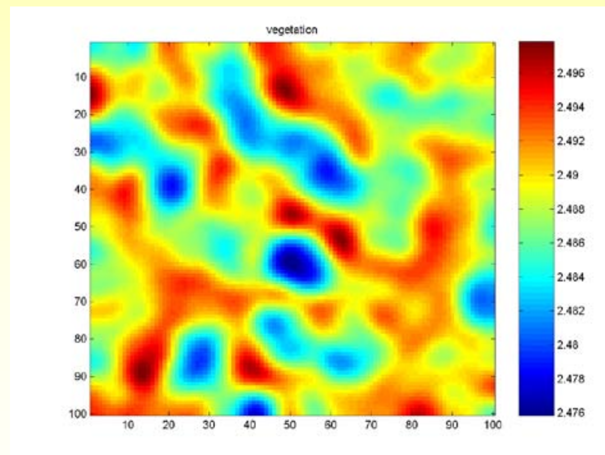
Original Model



$$f(P) = 0.015 + (0.035)\frac{P}{P_{\max}}; \alpha = 1$$



$$f(P) = 0.015 + (0.035)\frac{P}{P_{\max}}; \alpha = 0.5$$



$$f(P) = 0.015; \alpha = 0.5$$

Same result for: $f(P) = 0.015; \alpha = 1$