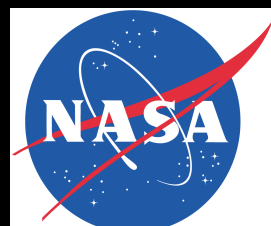


A New Method for Representing Subgrid Heterogeneity in Land Models

Ian Baker¹, **Piers Sellers**², Scott Denning¹, David Randall¹, Isaac Medina¹, Parker Kraus¹

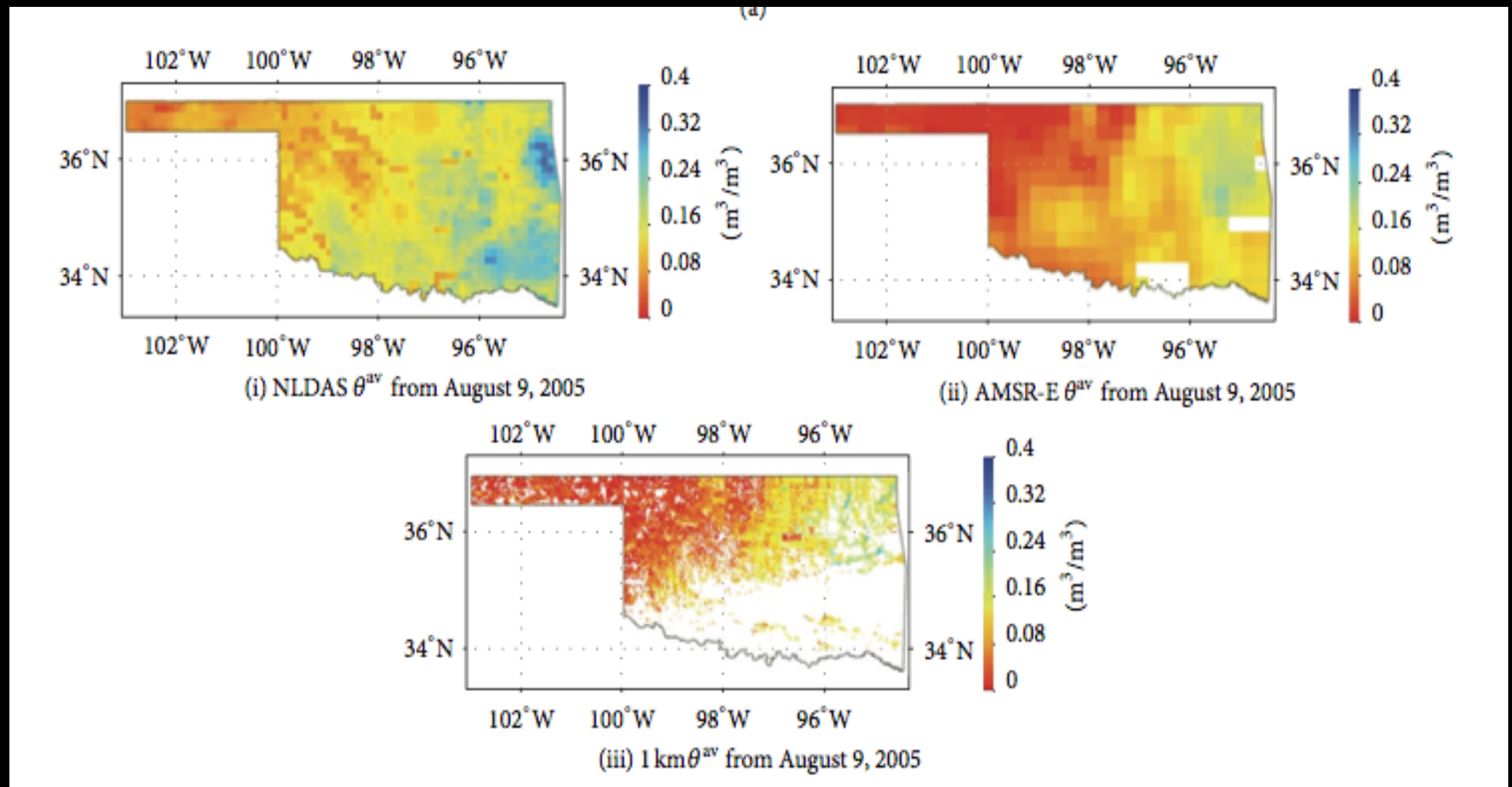
1: Colorado State University, Atmospheric Science Department

2: NASA, Goddard Space Flight Center

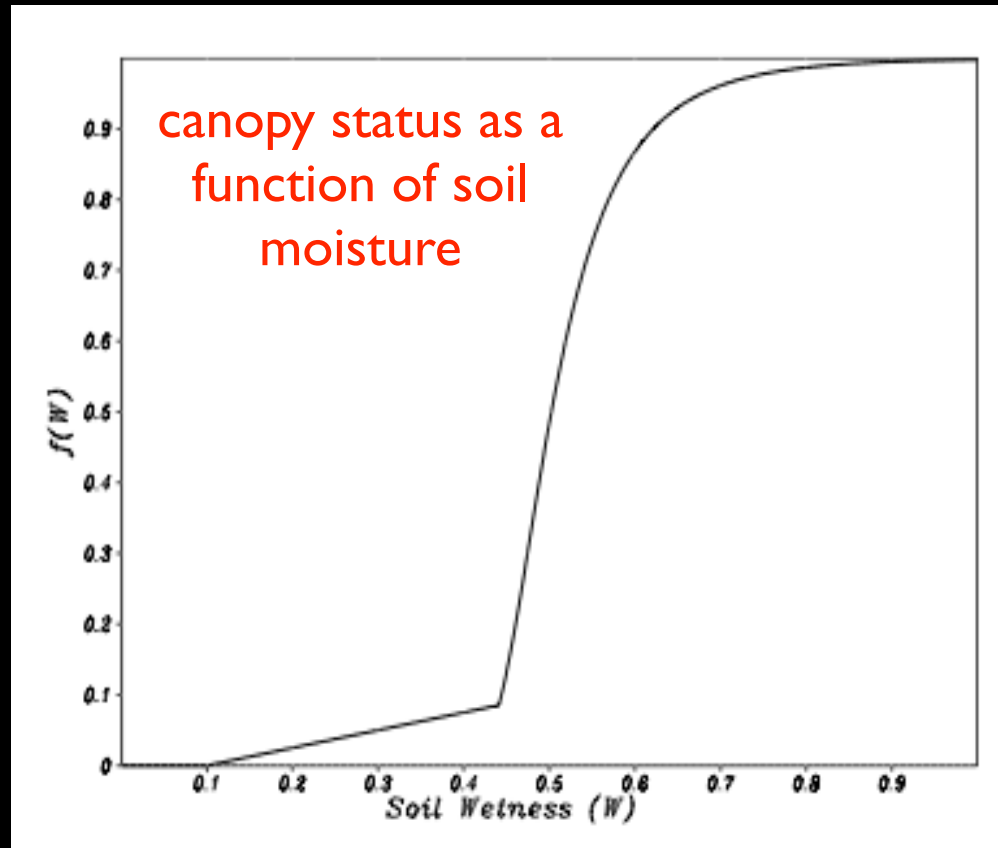


CMMAP Team Meeting, La Jolla CA, 13-15 Jan 2015

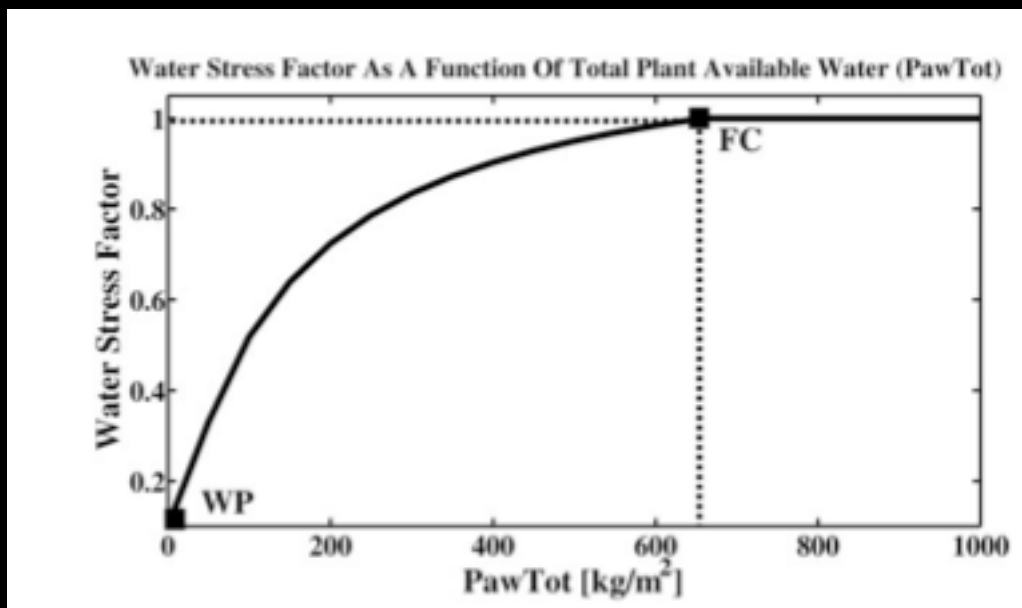
Soil Moisture Heterogeneity



Plant Response to Soil Moisture

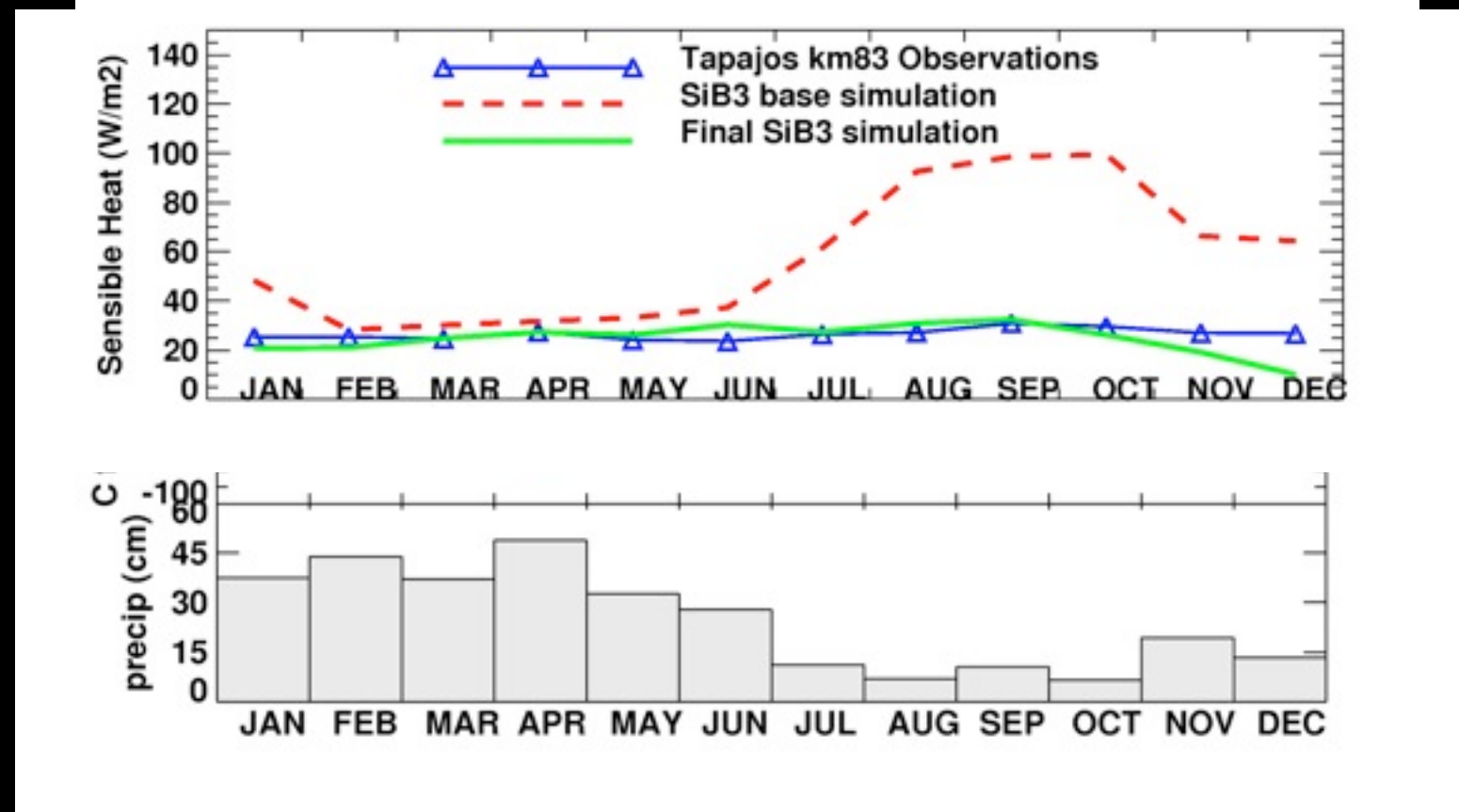
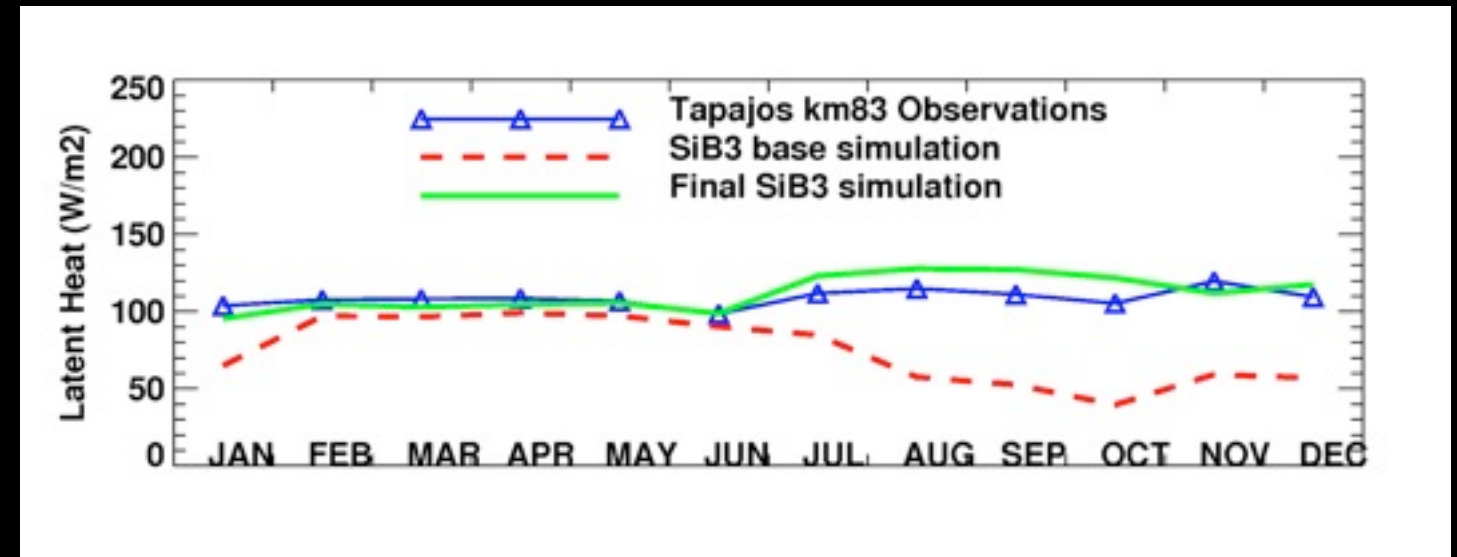


Data from FIFE (Colello et al., 1998)



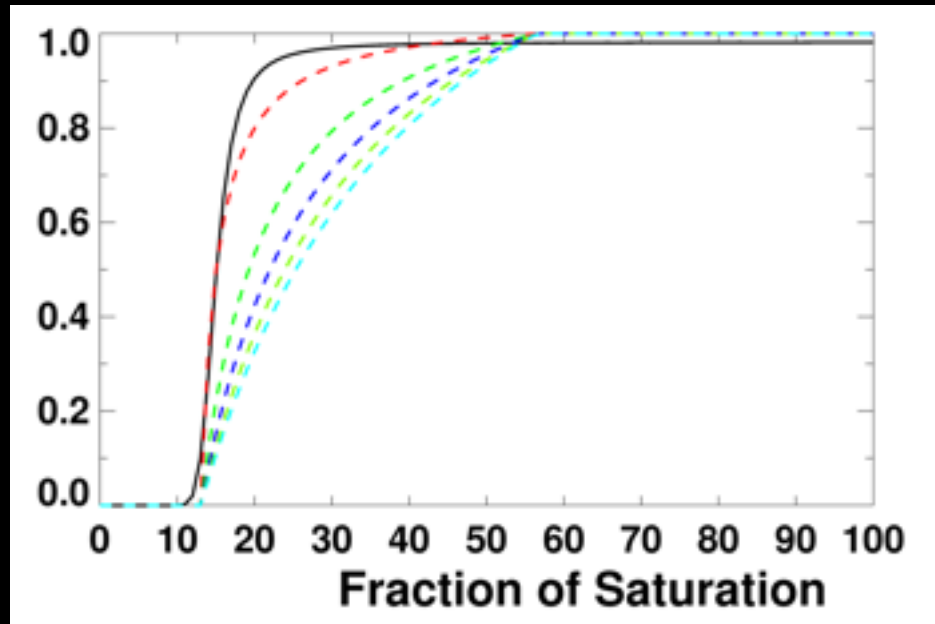
Parameterized evaporation control:
Baker et al. (2008), Medina et al. (2014)

Baker et al. (2008)



The problem with doing it this way

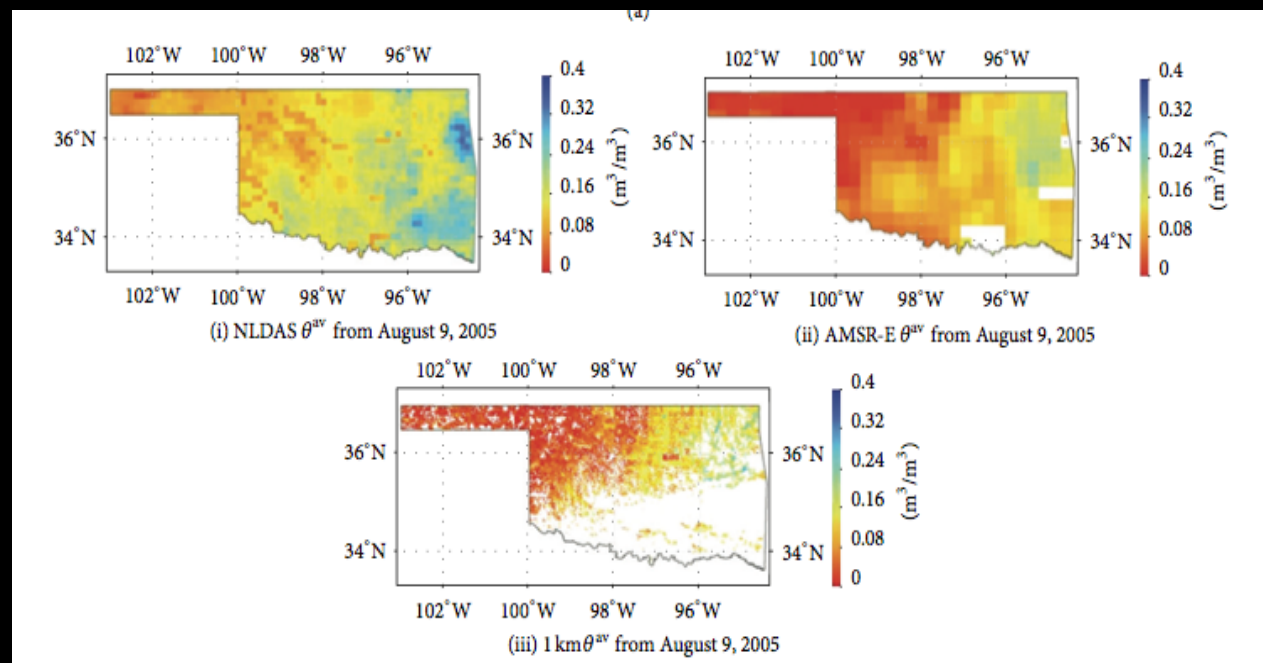
$f(w)$



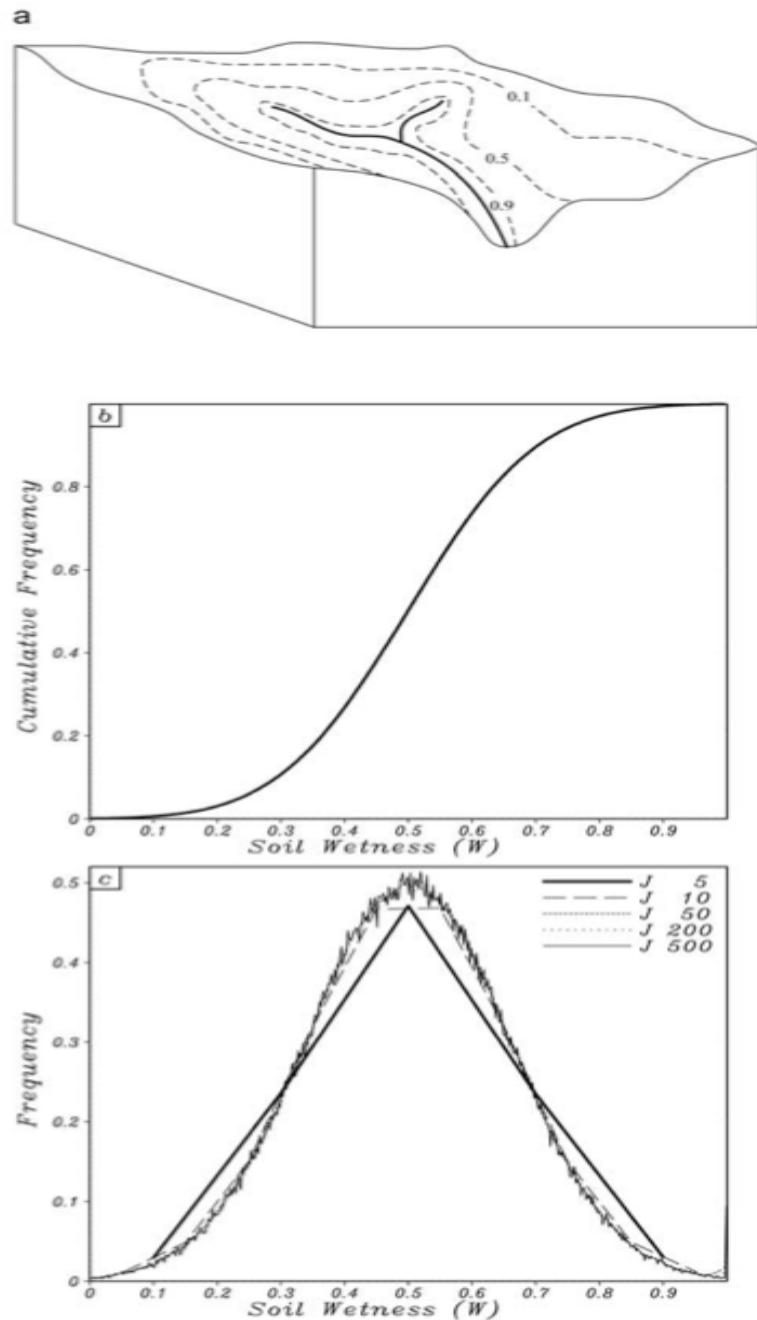
$$E = E_p f(W)$$

$$\langle E \rangle \neq E_p f(\langle W \rangle)$$

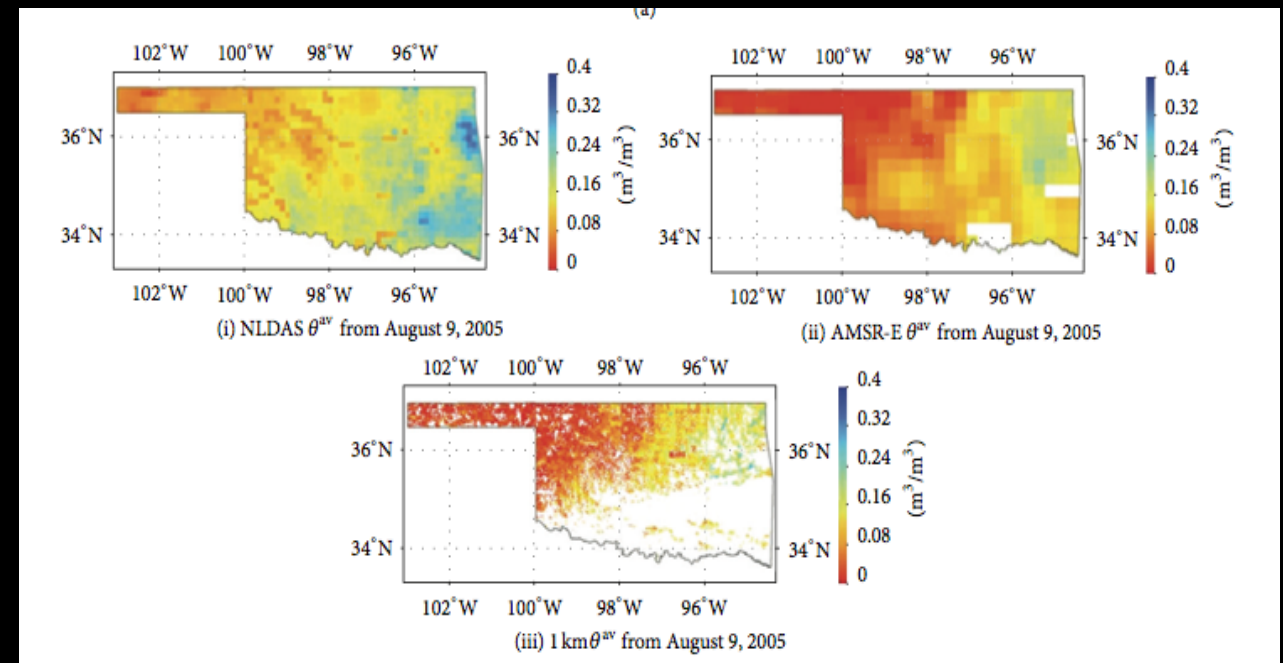
$$\overline{f(x)} \neq f(\bar{x})$$



A New Approach: Wetness Bins



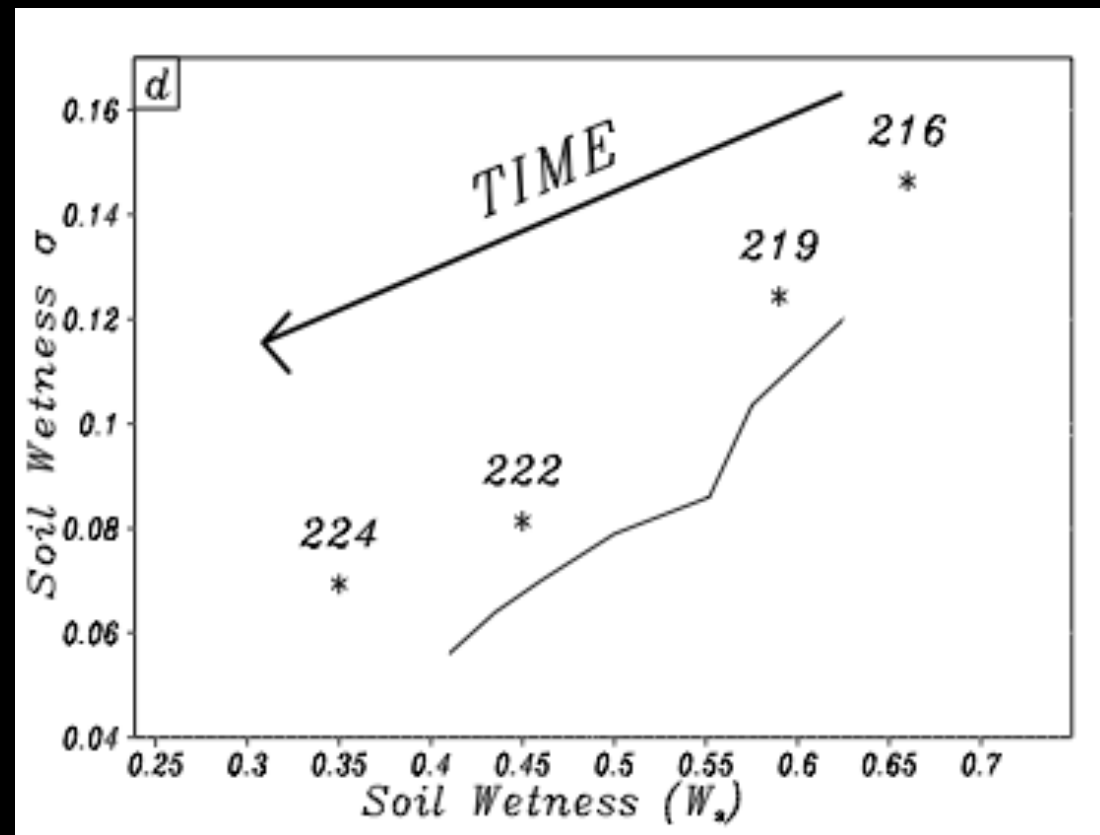
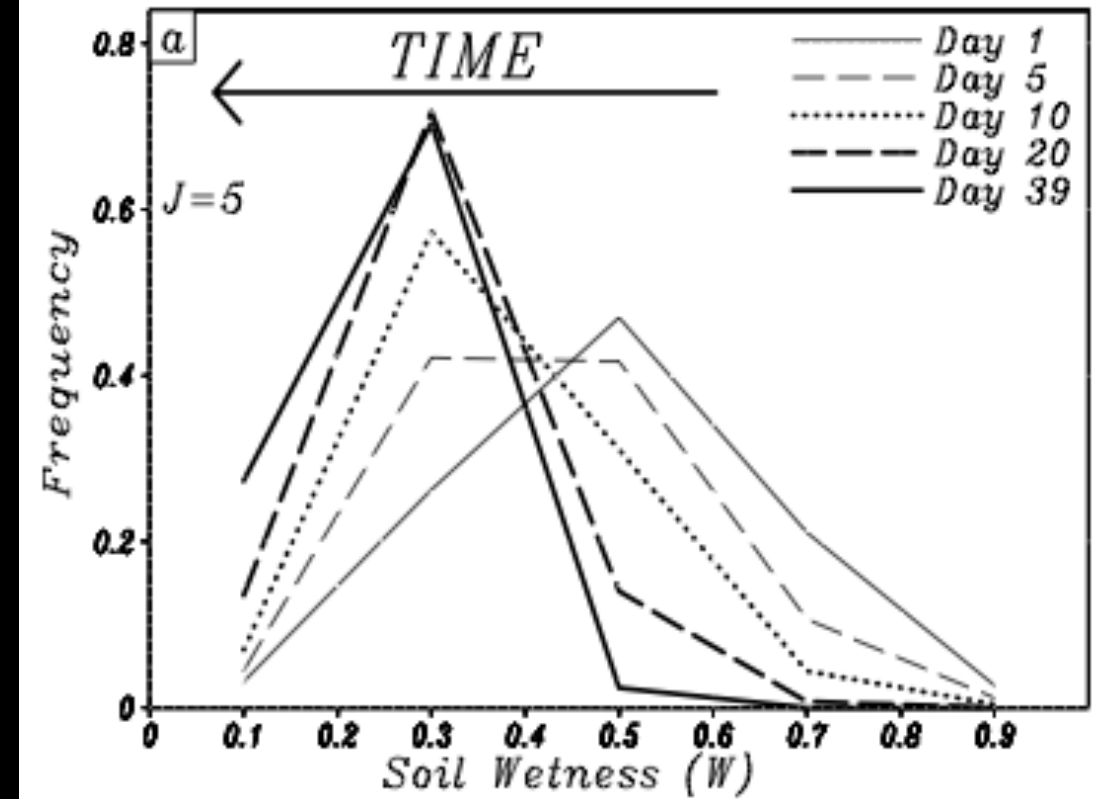
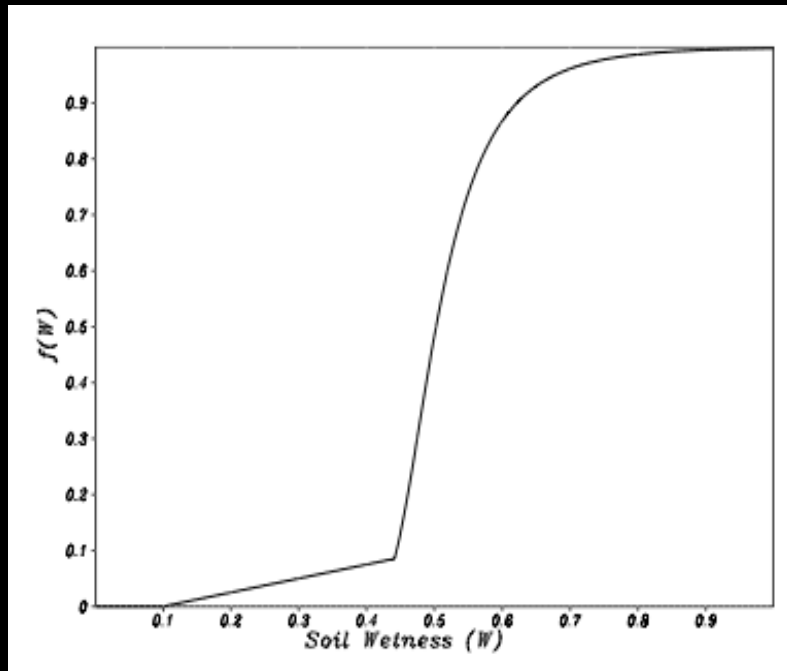
Several ways to
consider wetness: from
Sellers et al. (2007)



- We can define a finite number of 'bins' within the model to represent spatial variability in wetness

Toy Model

(Sellers et al., 2007)



$$\langle E \rangle = E_p \int_A f(W) da$$

$$\int_A f(W) da \sim \sum_{j=1}^{nbins} f(W_j) a_j$$

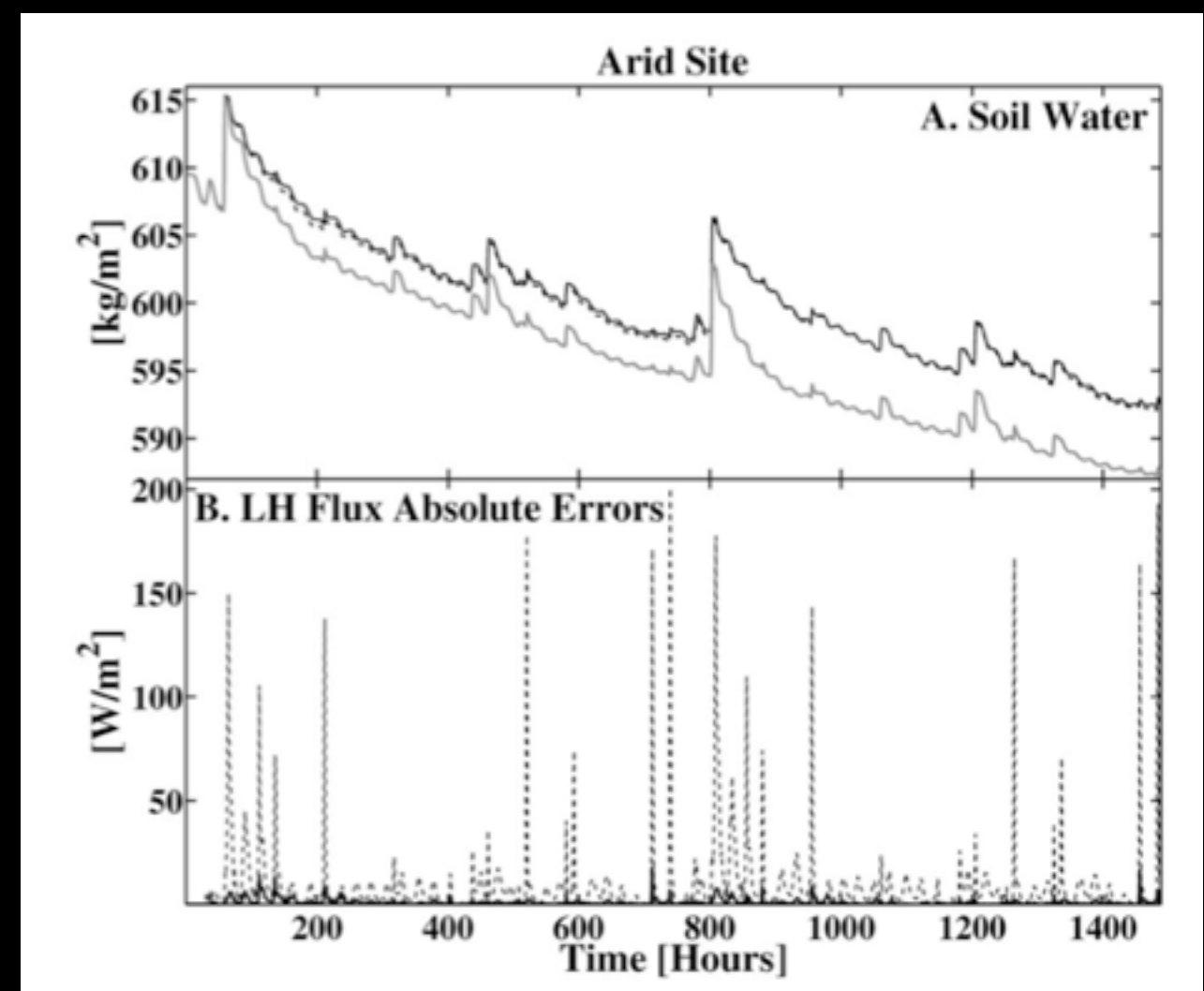
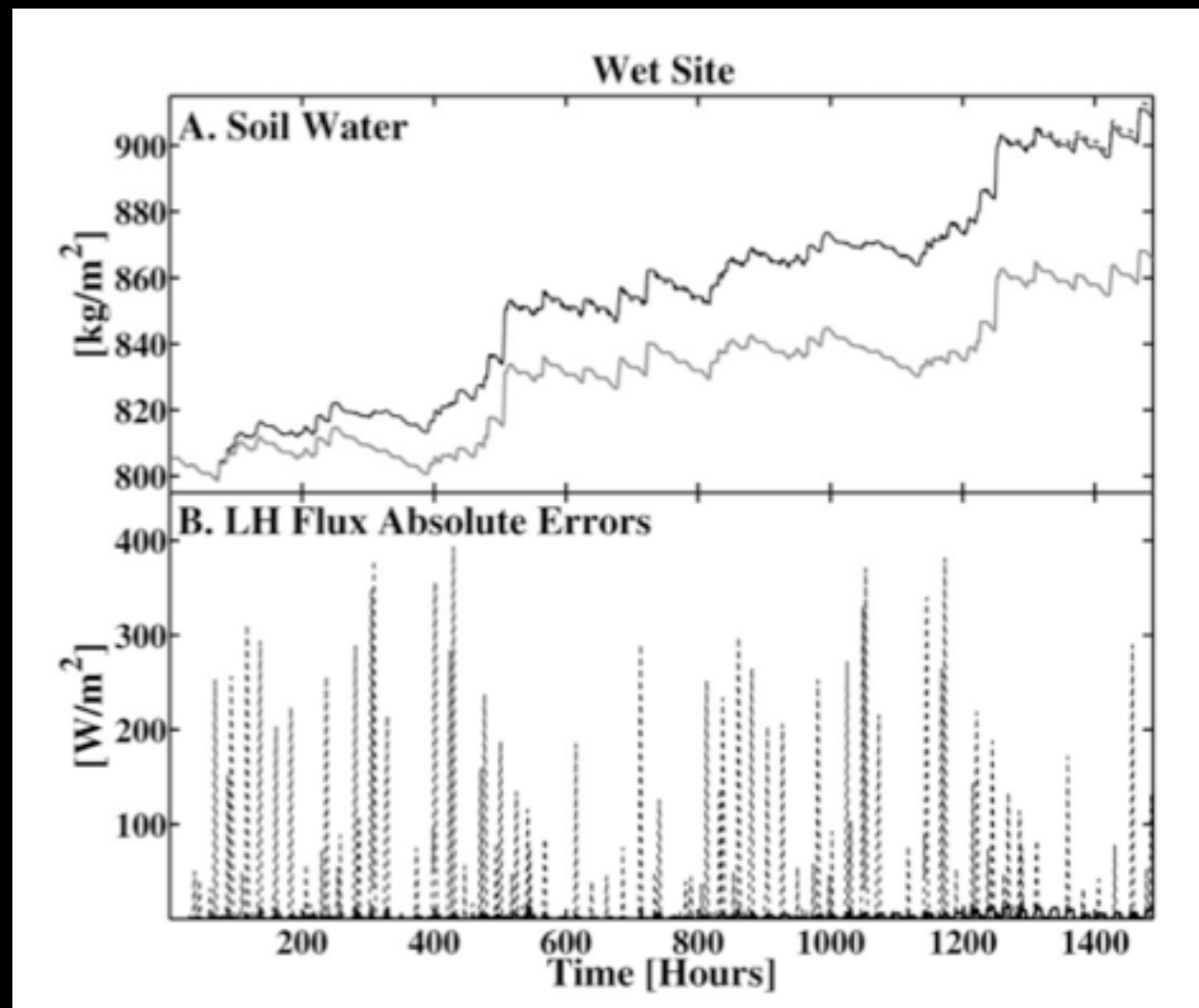
From the Toy to the Full Model

- Medina et al., JAMES, 2014

black = $\overline{f(x)}$

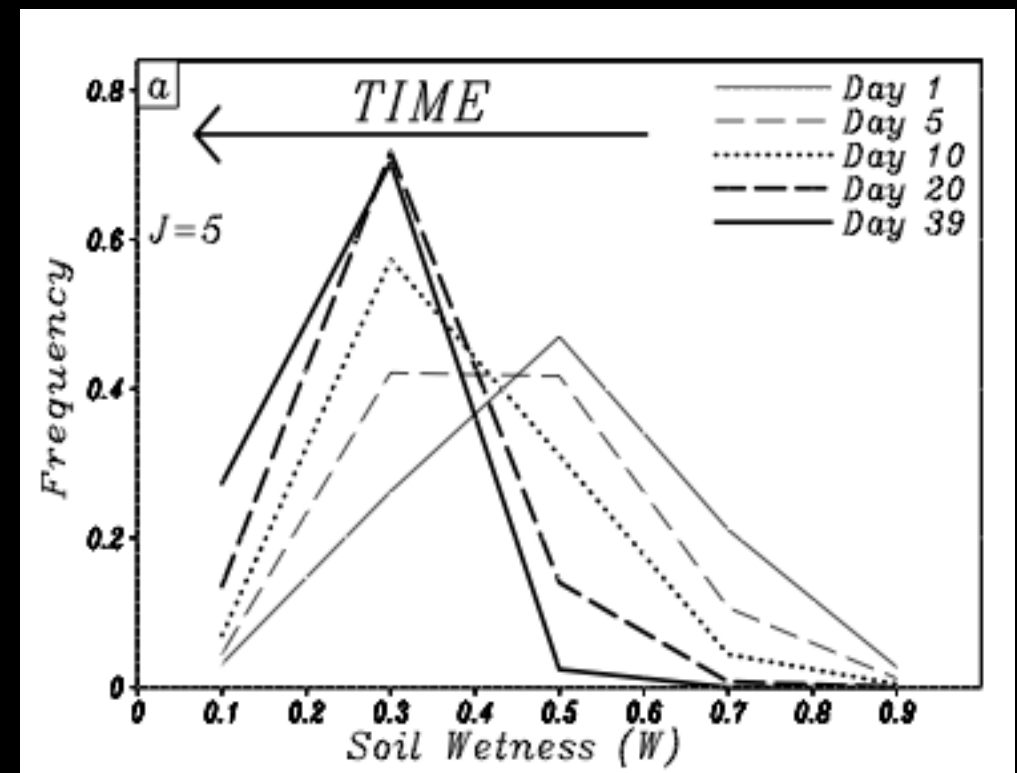
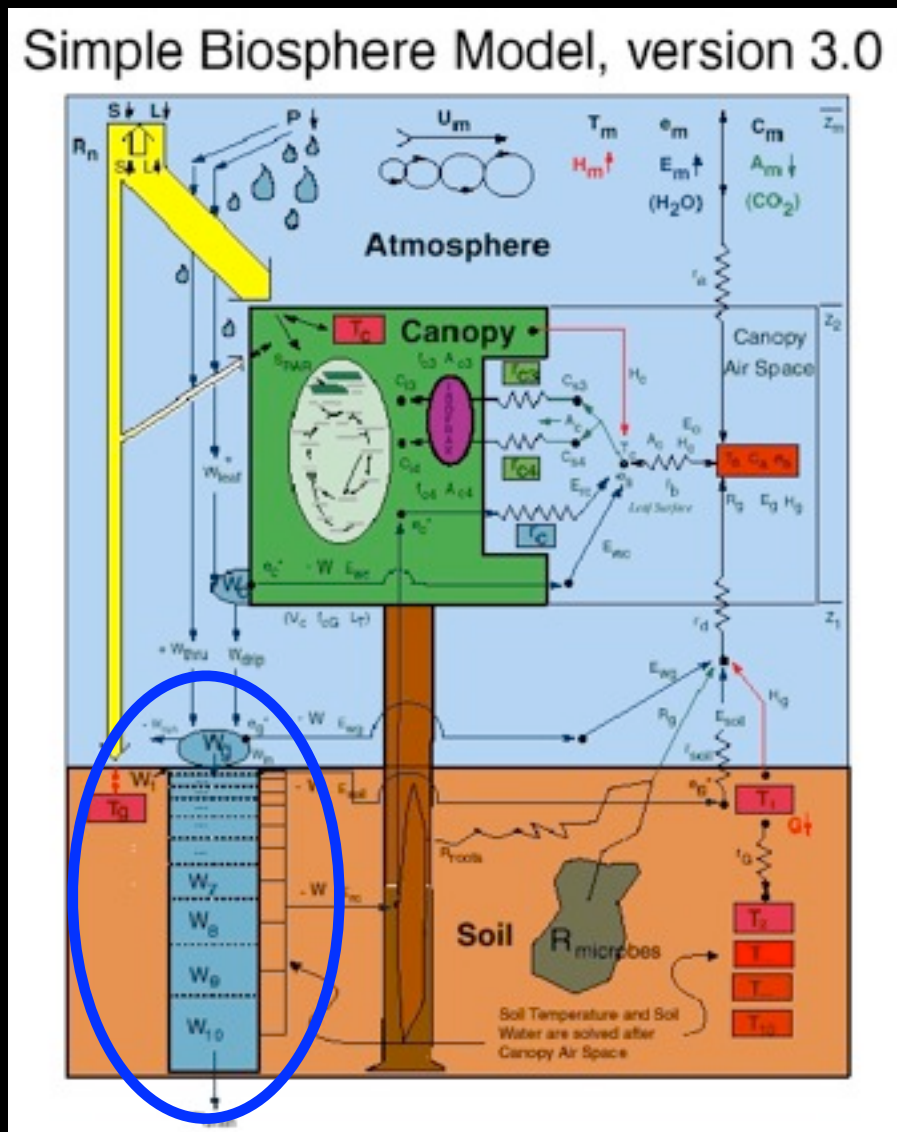
gray = $f(\bar{x})$

dashed = bins



From the Toy to the Full Model

- PROBLEM: How can we reconcile a single 'wetness' bin with a vertically-variable soil column?



Solution: Modify Model Sequence

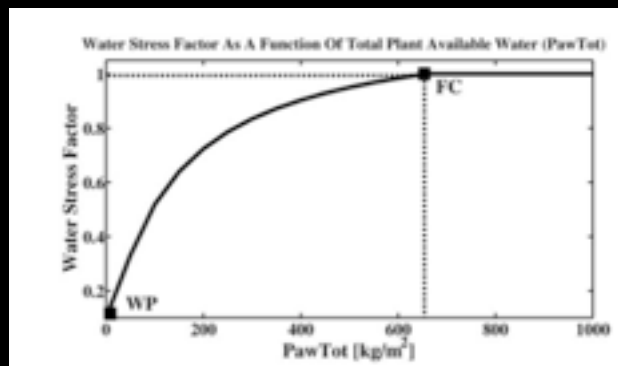
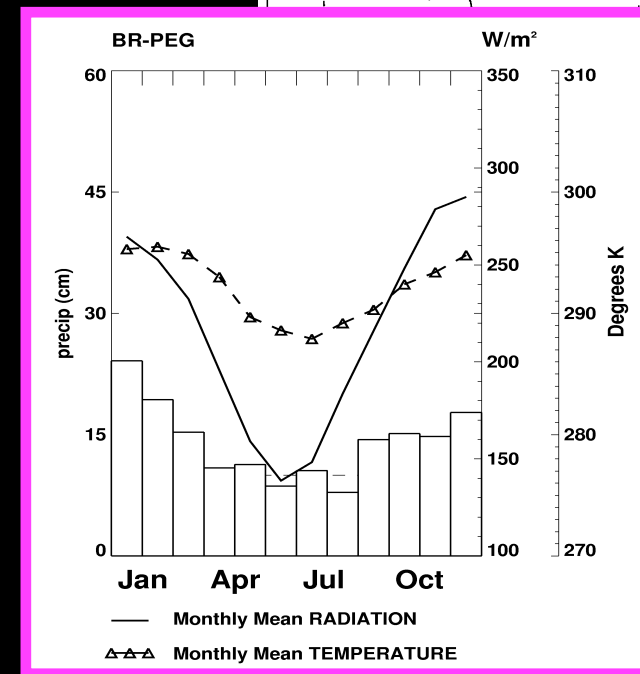
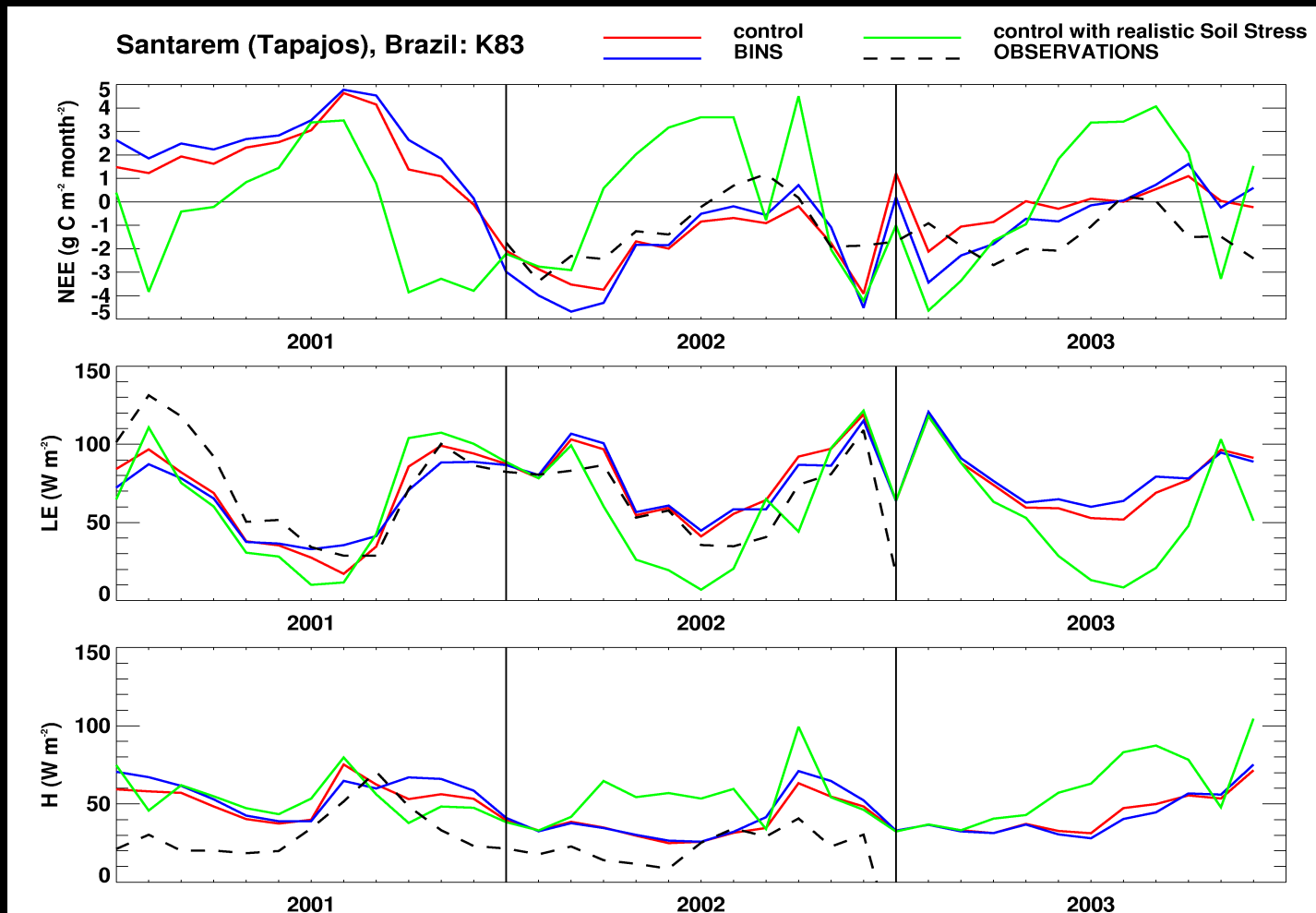
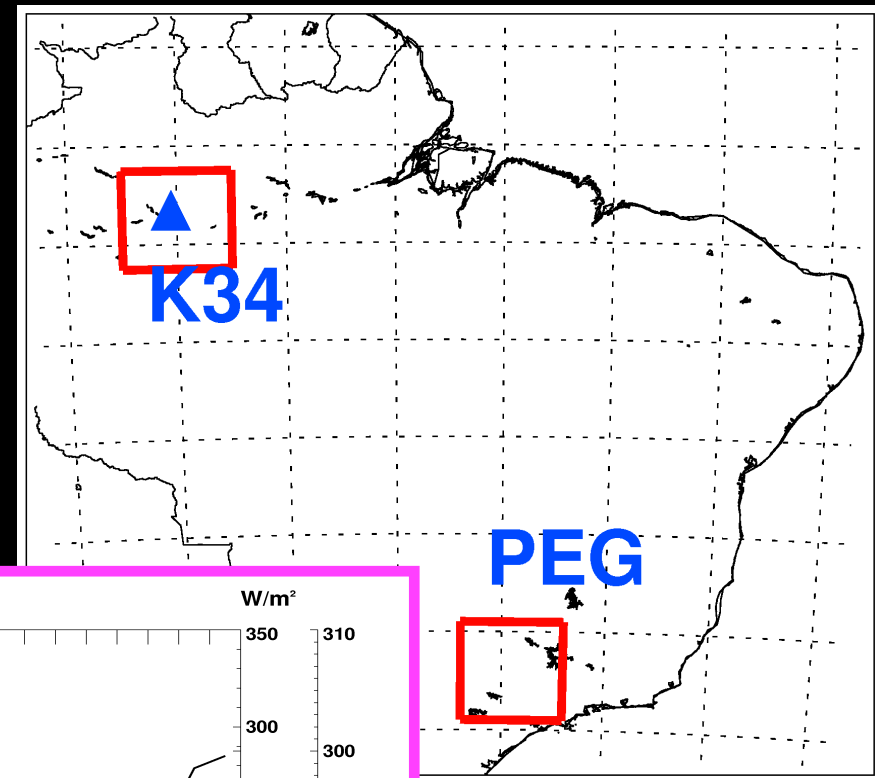


1. Precipitation onto canopy (throughfall, drainage)
2. Surface interception/runoff/infiltration
3. Update bins/z-column
4. Determine stress $f(W)$
5. Calculate Energy/Moisture exchange
6. Remove water from soil (transpiration)
7. Update bins/z-column

$$\int_A f(W) da \sim \sum_{j=1}^{nbins} f(W_j) a_j$$

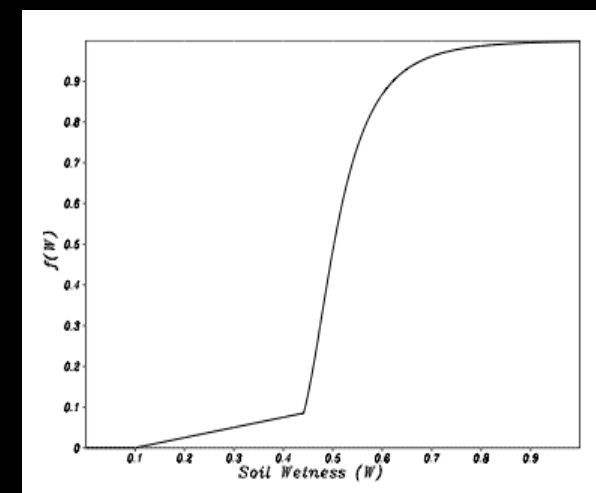
$$\sum_{j=1}^{nbins} W_j a_j = \sum_{i=1}^{nsoil} W_i, z_i$$

Results: A Site That Works (PEG)

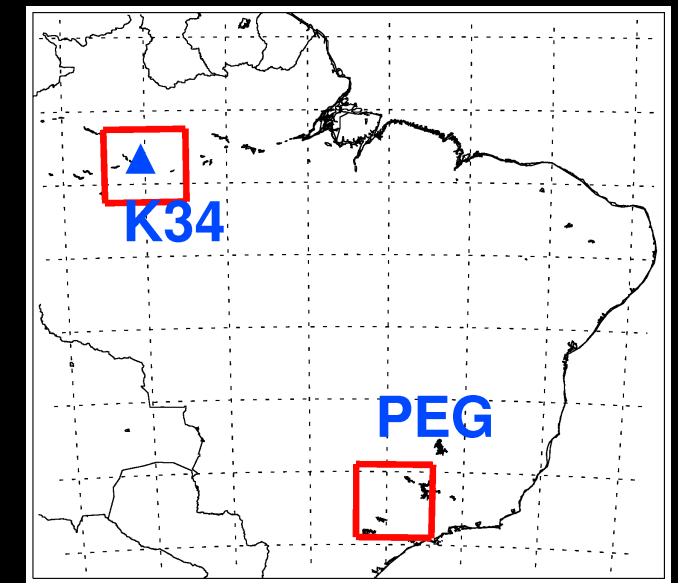
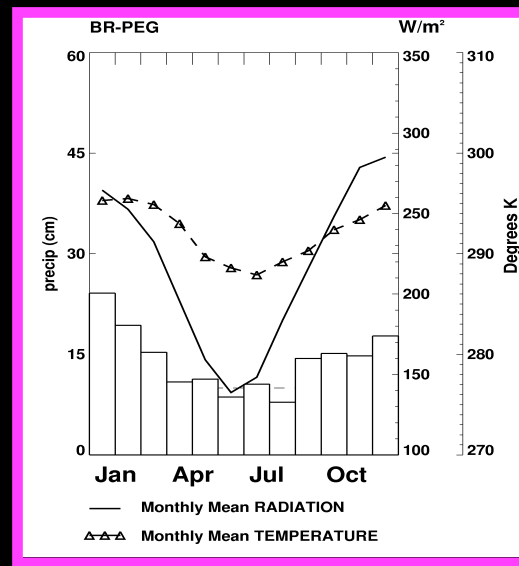


$f(w)$ for the control run (red)

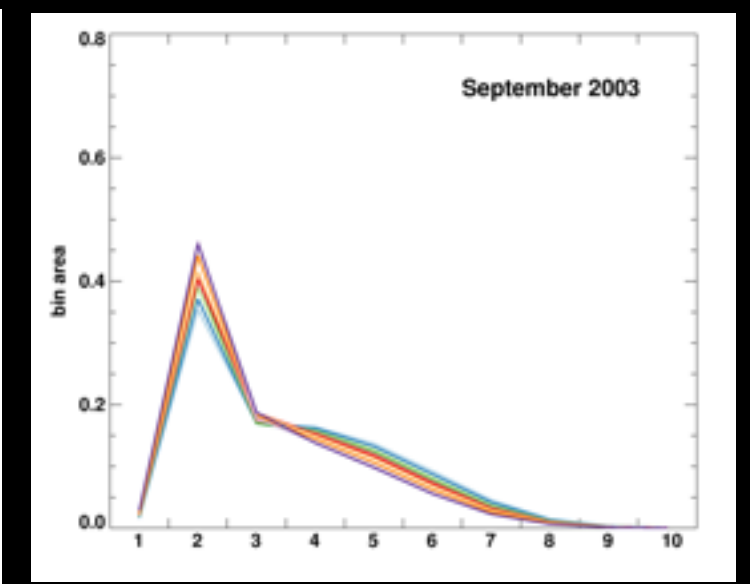
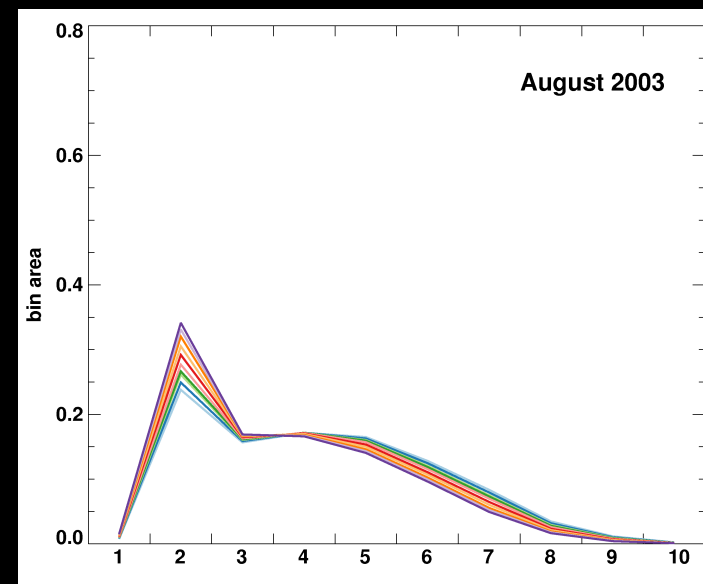
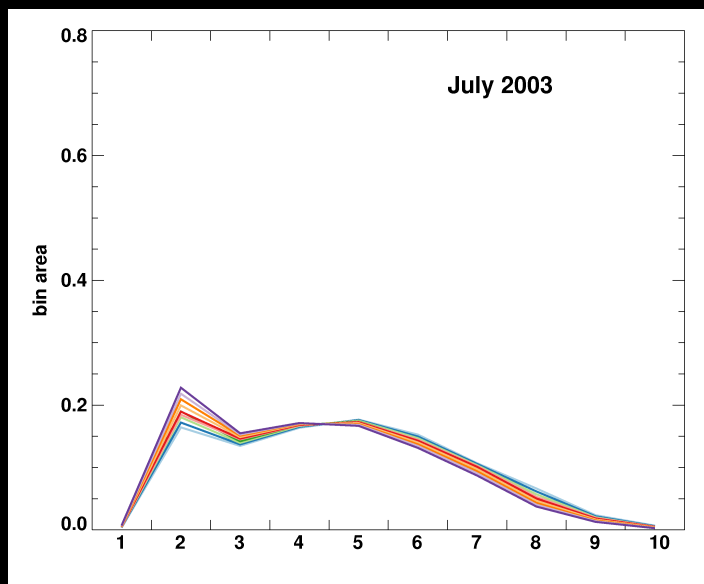
$f(w)$ for 'control w/ realistic' (green) and bin (blue) runs



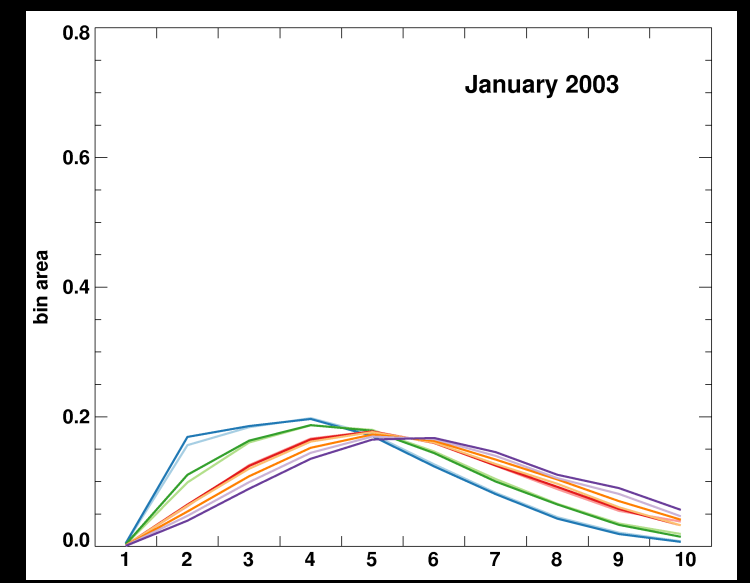
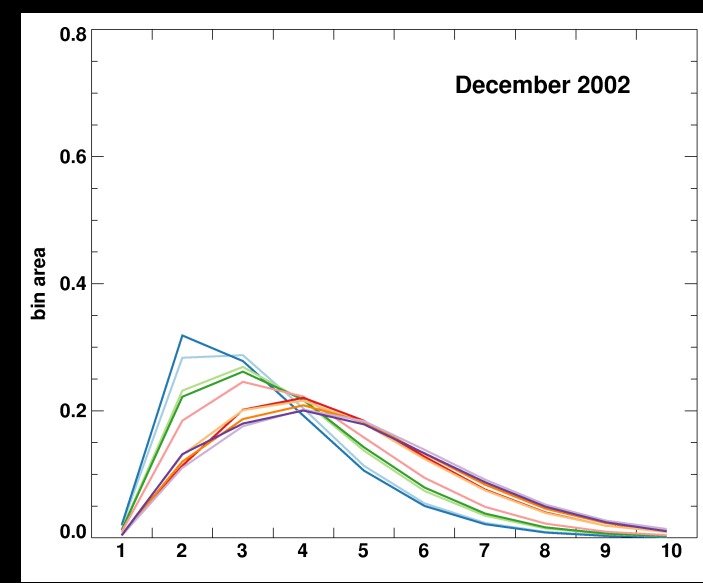
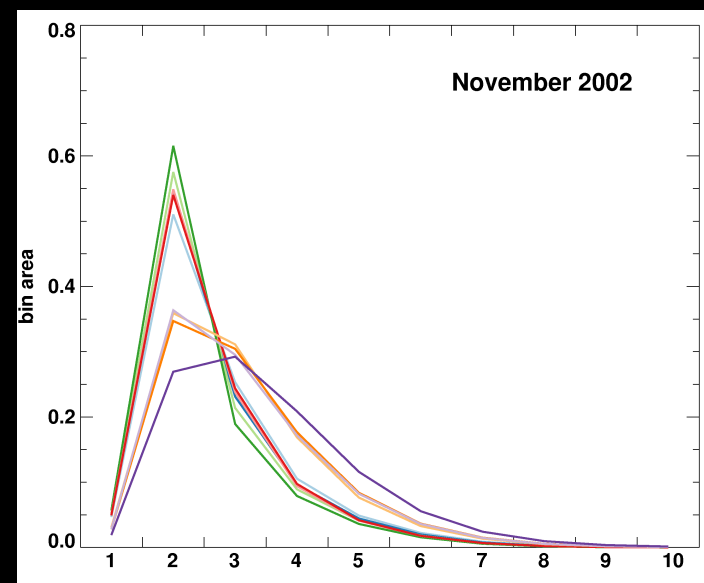
Results: A Site That Works (PEG)



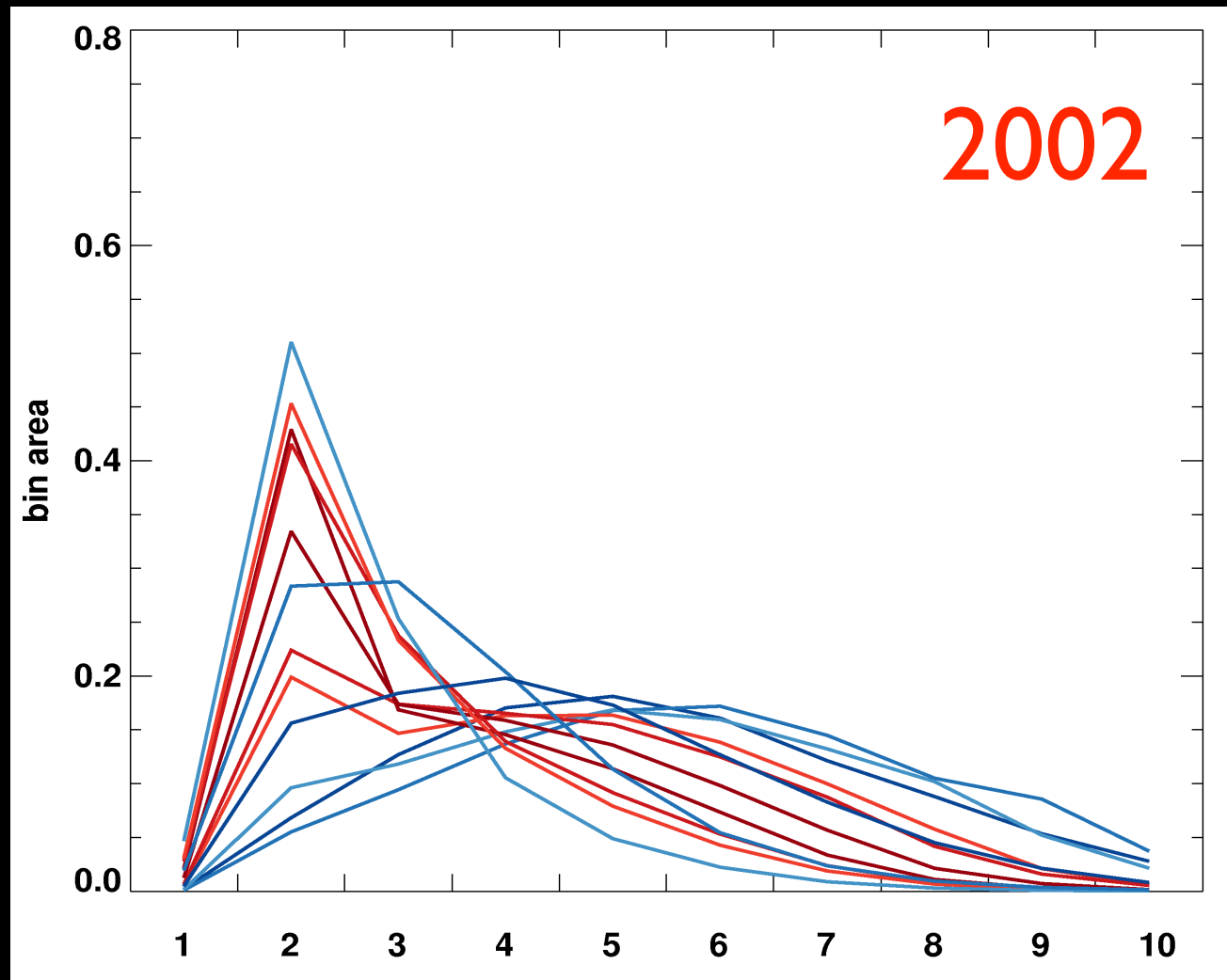
Drying



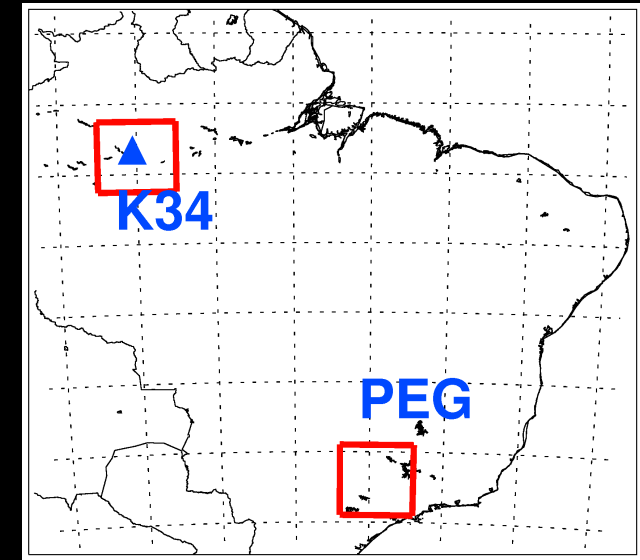
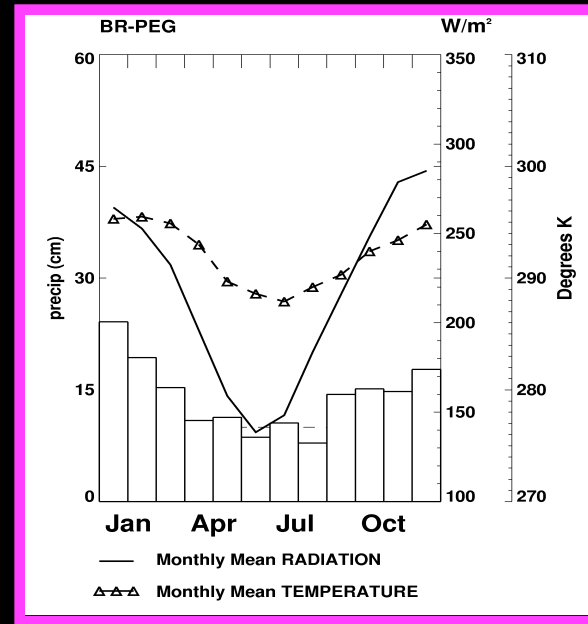
Moistening



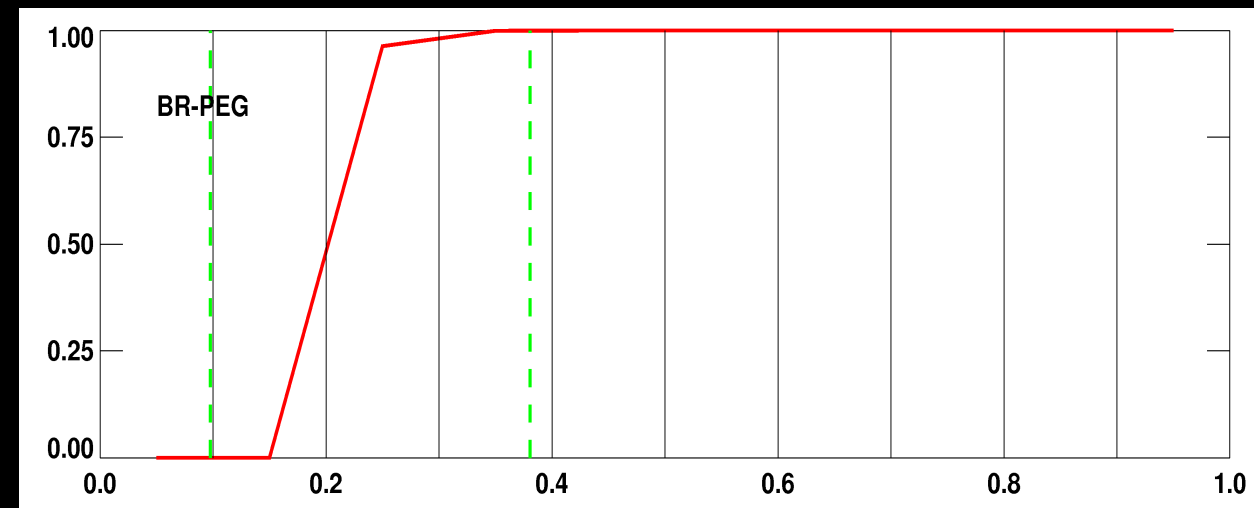
Results: A Site That Works



bin number

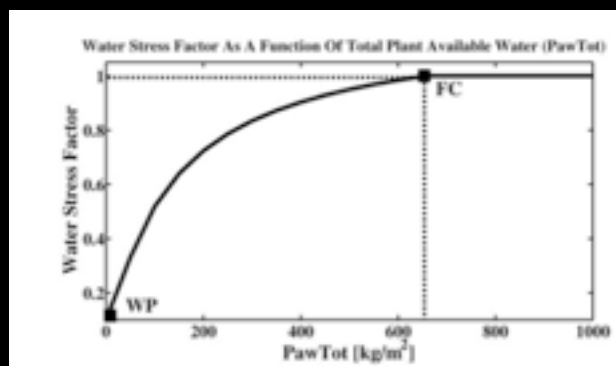
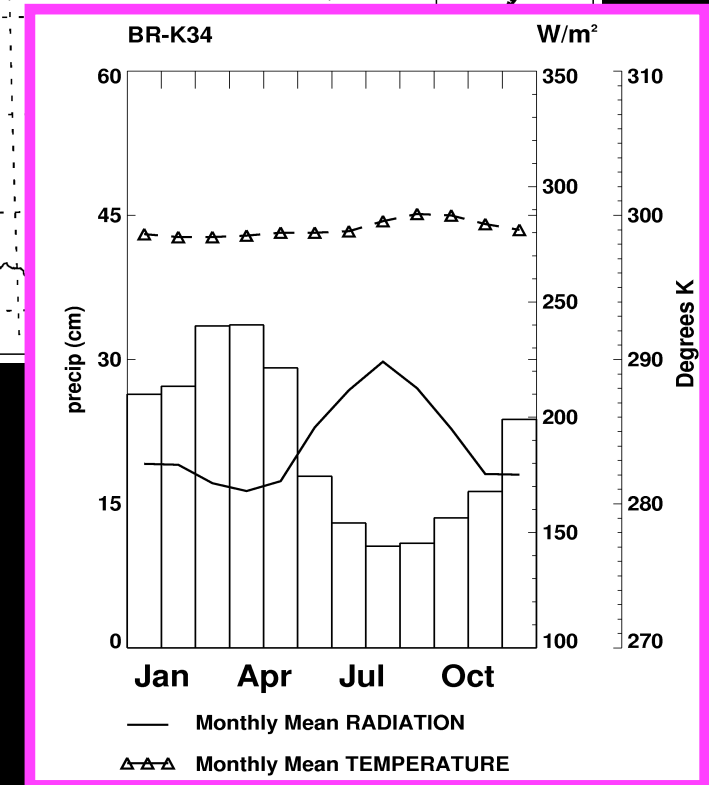
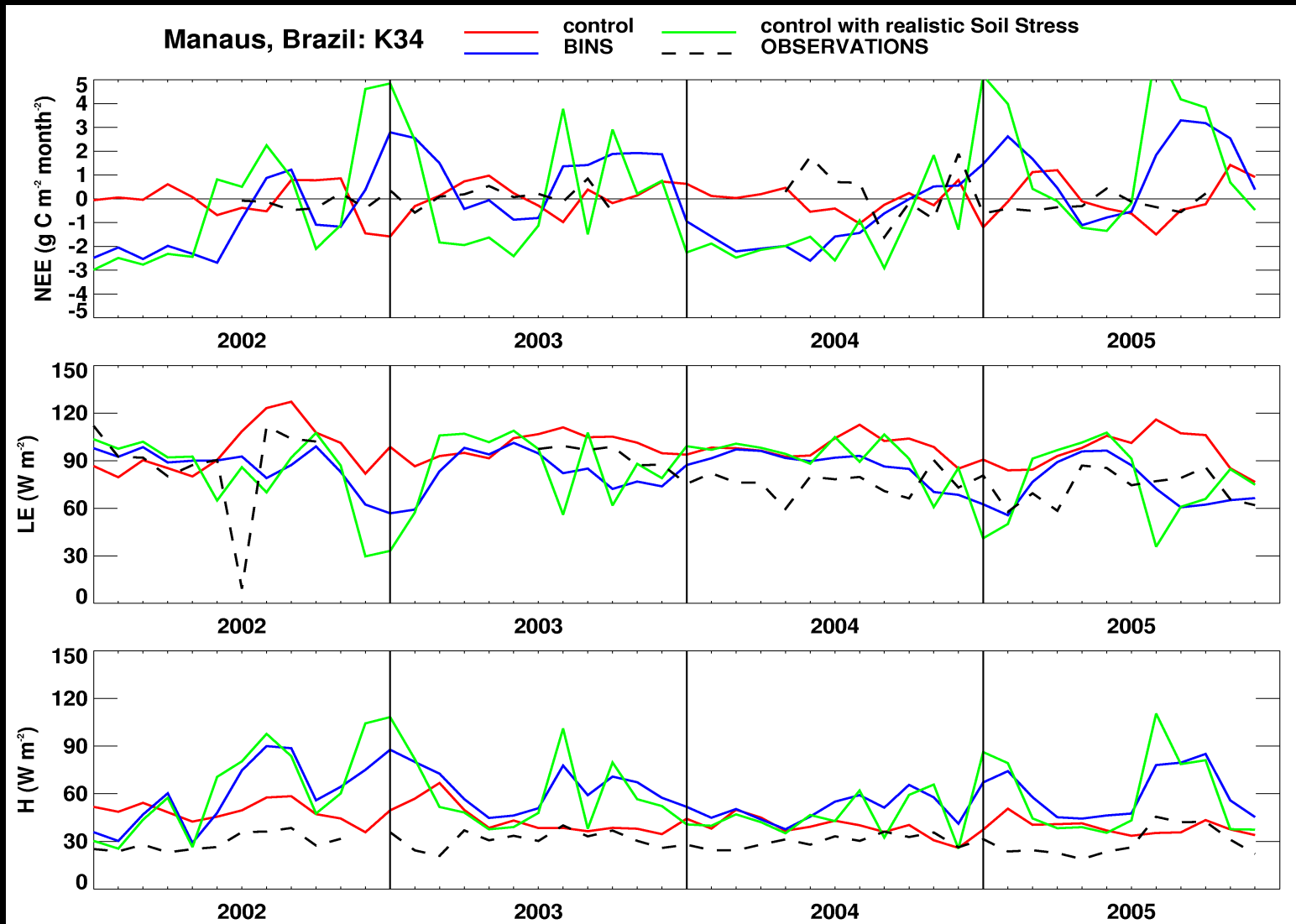
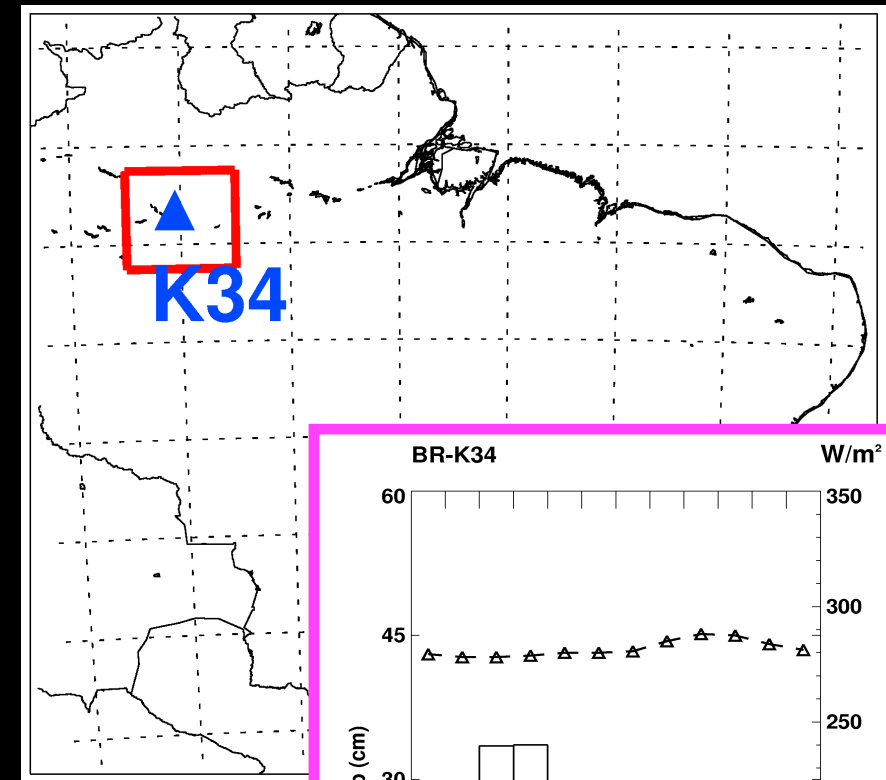


evaporation control $f(w)$



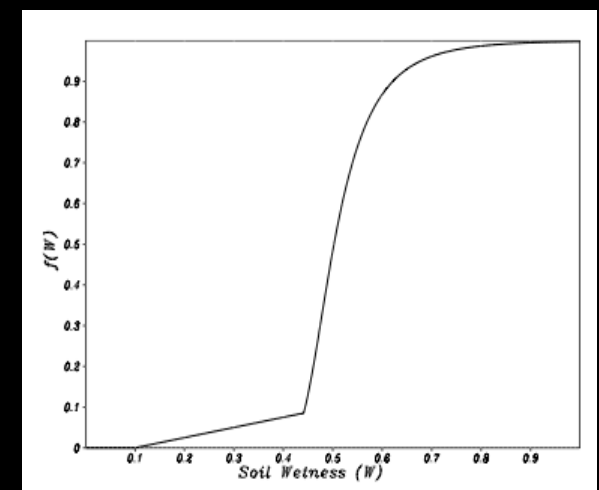
fraction of saturation/bin

Results: A Site That Doesn't Work

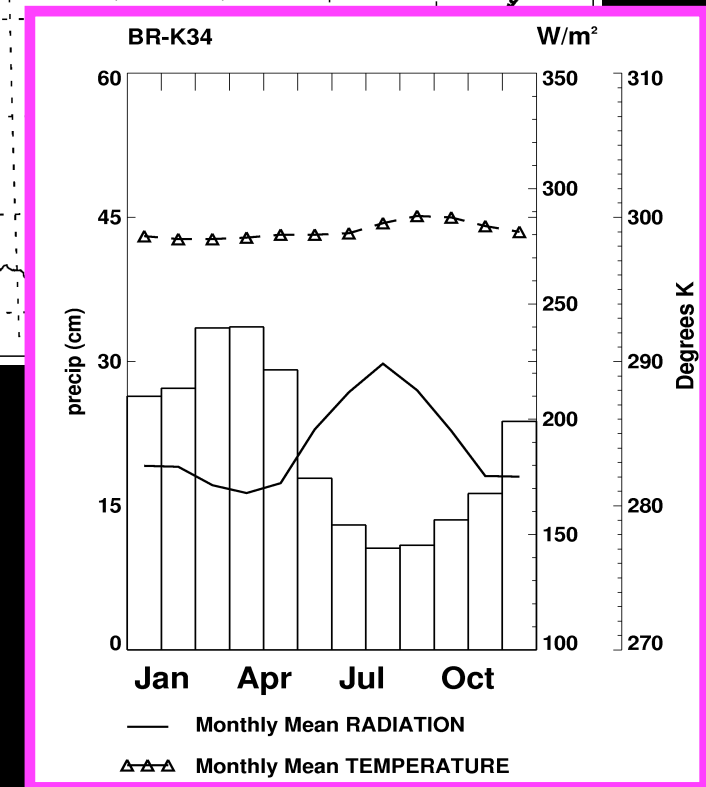
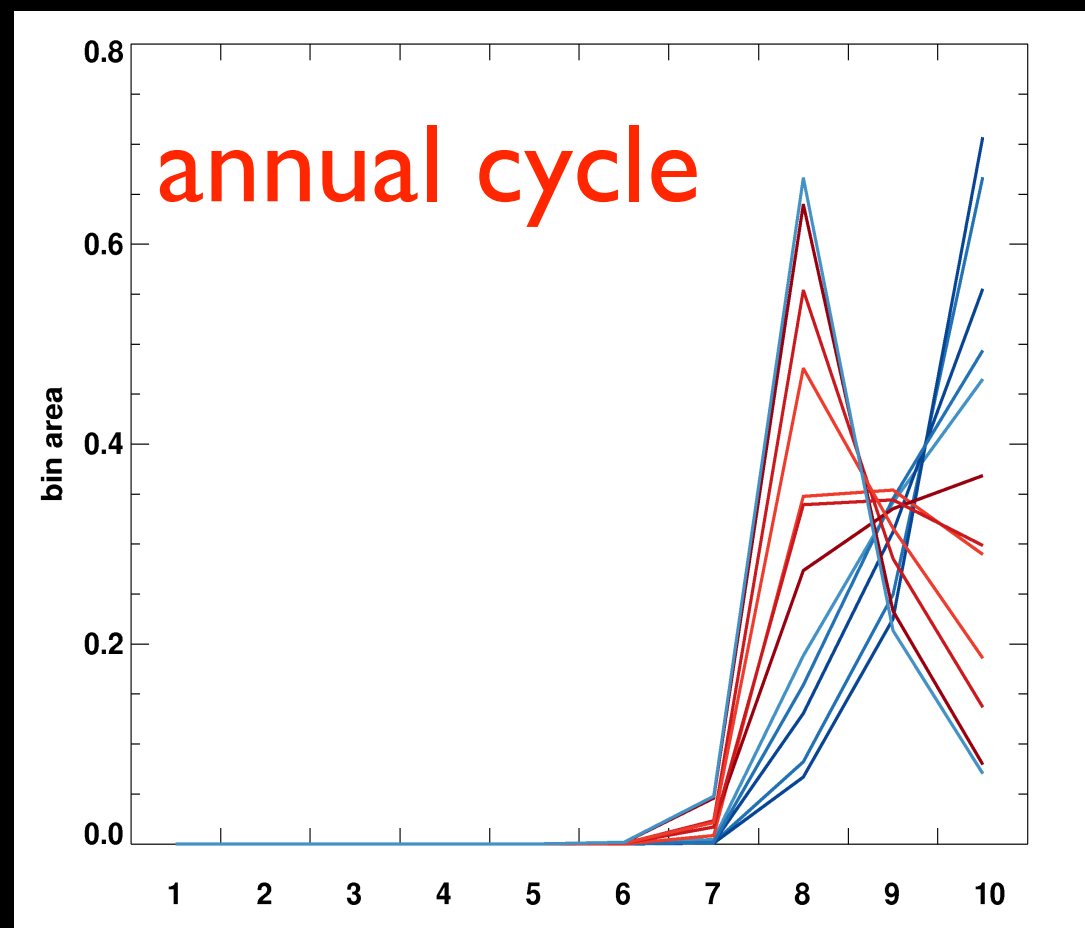
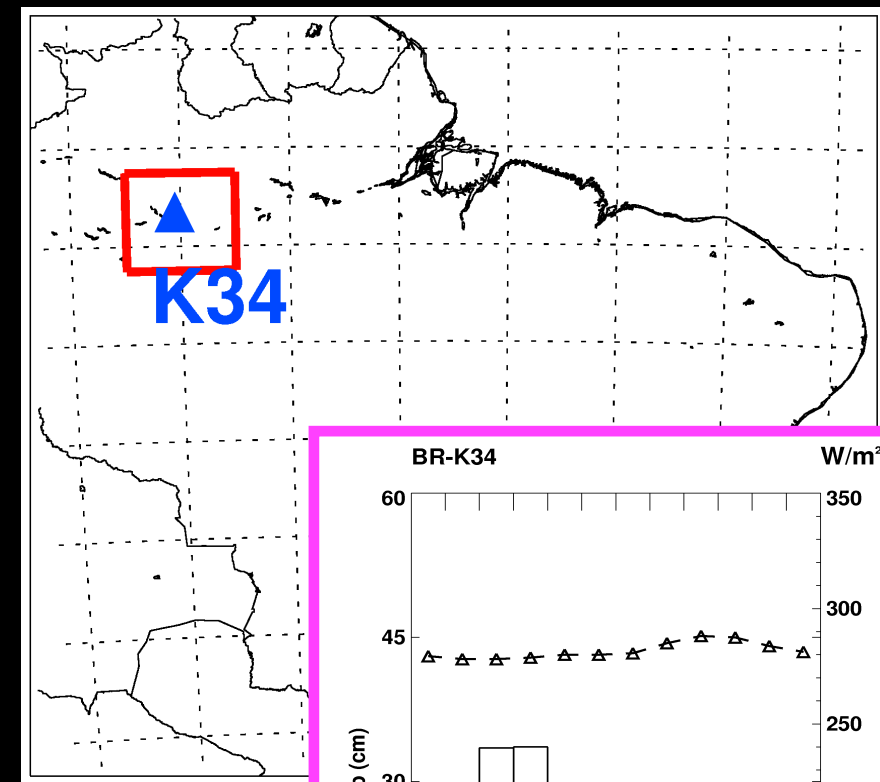


$f(w)$ for the control run (red)

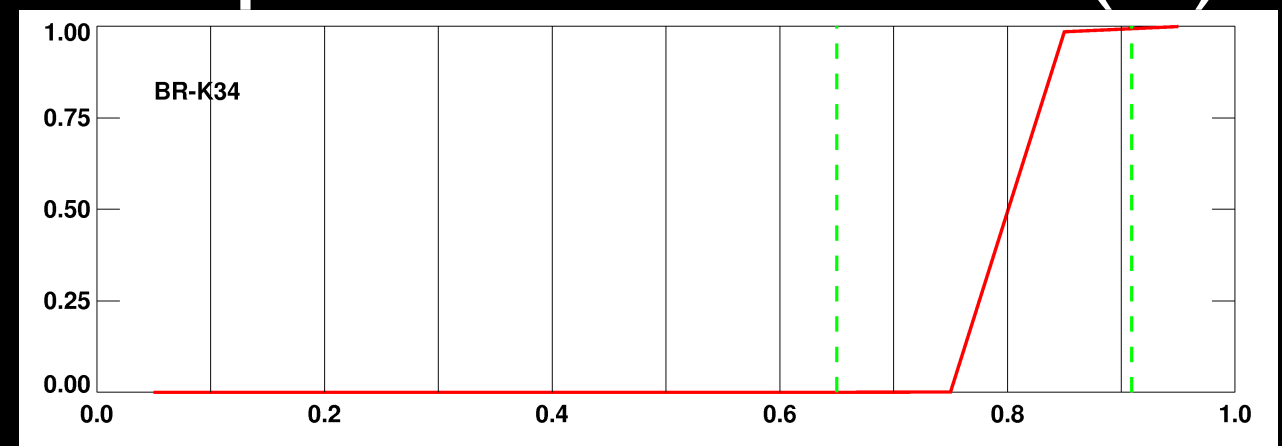
$f(w)$ for 'control w/ realistic' (green) and bin (blue) runs



Results: A Site That Doesn't Work



evaporation control $f(w)$



fraction of saturation/bin

Conclusions

- The bins work quite well in semi-arid to arid regions
- Some problems in wet tropical forests
- Code is robust to bin number, bin spacing
- Energy and water balance to machine precision (bin- and z-columns)

Implementation

- Should we see bins as an alternative to CRMs?
- Are bins a complement to MASL?
- Or would bins coupled to MAML provide a link to hydrology?

QUESTIONS?



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Deployed NGEA-Arctic Tram
Stan Wullschlegel¹
Laboratory

Daily

B53A-0171 A New Scaling Approach for Calculating Realistic Energy, Water and Carbon Fluxes from GCM Grid Areas.

Piers Sellers¹, Ian Baker², A. Scott Denning²,
David A. Randall², Isaac Medina², Kyrus²

FLOW CHART

1. Precipitation (Schmitz/Janowiak) -> canopy
2. Update time (cell/month) -> determine stress (Eq 1, Eq 2)
3. calculate area-mean SFC -> Net Radiation -> photosynthesis/transpiration -> LE, H
4. calculate water -> Net Evaporation -> ET removal
5. Update time

ABSTRACT

The calculation of grid-averaged energy, water and carbon fluxes from GCM grid areas is a challenging task whenever the dependent variable, e.g. evapotranspiration, is a spatially-varying independent variable, eg. soil moisture. A dynamic binning scheme is used to capture the spatial variability of soil moisture using a small number of bins. The grid-averaged calculation of evapotranspiration is then based on the bin contents and thereby realistically model the resulting carbon fluxes. This approach was previously demonstrated in a simple "toy" soil moisture-temperature model. The current approach has recently been implemented in a 1-d version of the Community Land Model (CLM) and its performance is being evaluated. The approach is shown to produce realistic fluxes of energy, water and carbon fluxes.

4. RESULTS - A SITE THAT WORKS - Fe de Gignon

3. Implementing the bin scheme into SiB3 code

The SiB3 code is a one-box parameterization for use in models that require realistic surface energy balance of vegetation, atmosphere, land, snow and sea ice for regional and global-scale climate simulations. The main challenge was to integrate the bin scheme into SiB3 code.

The bin scheme will be used to calculate the grid-averaged energy, water and carbon fluxes from GCM grid areas. It is also used to calculate the vertical fluxes of water and heat from the surface to the atmosphere. The bin scheme is also used to calculate the vertical fluxes of water and heat from the surface to the atmosphere.

AND ONE THAT DOESN'T

Towards the spatial

Objectives

- Ex
- Up

Methodology and Results

US-PT 447 in full tower

Measurement height: 122 m

and outlook

- Ex
- Up