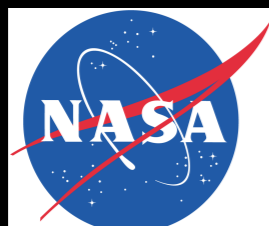


A New Method for Representing Subgrid Heterogeneity in Land Models

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

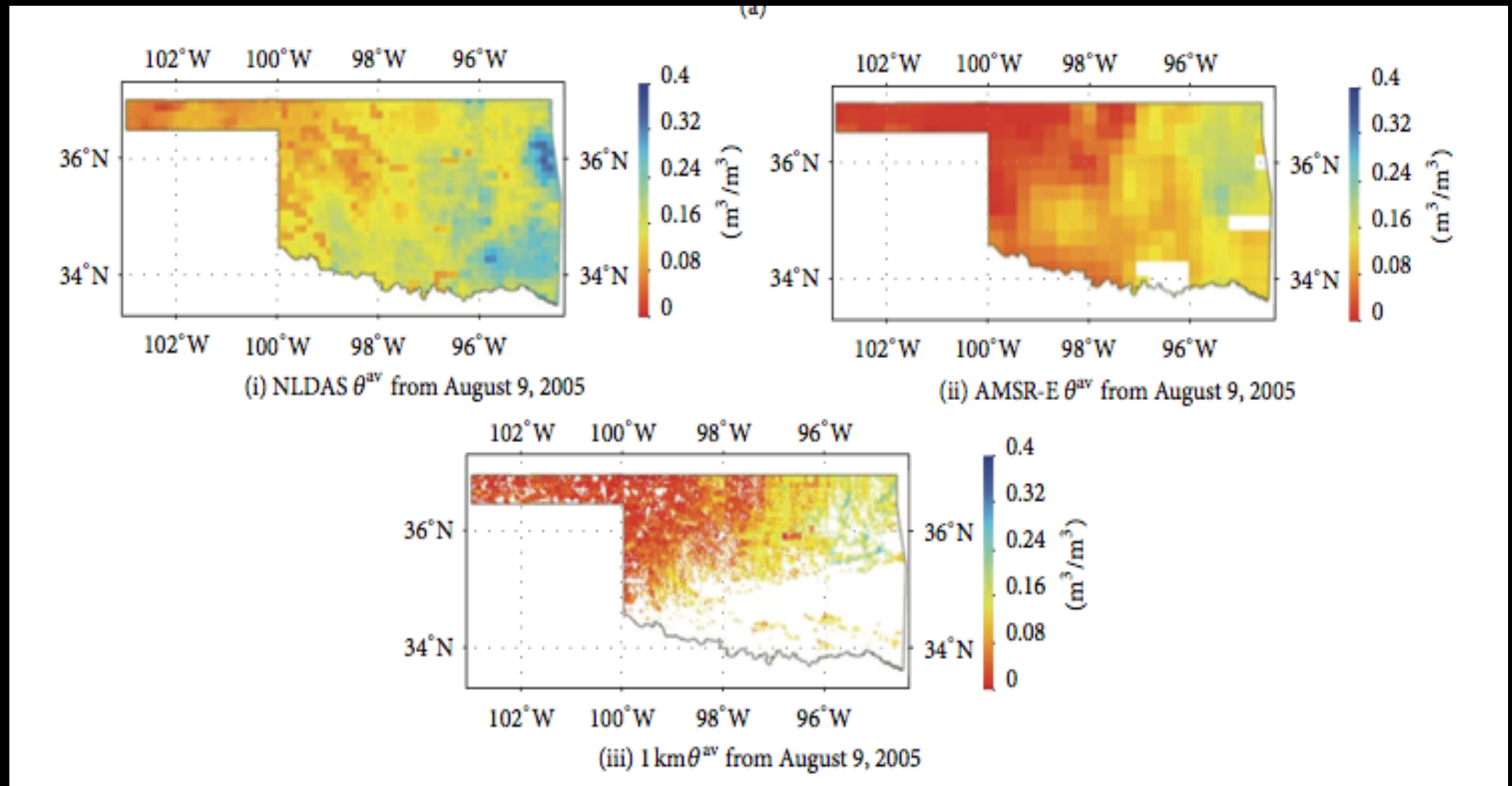
1: Colorado State University, Atmospheric Science Department

2: NASA, Goddard Space Flight Center

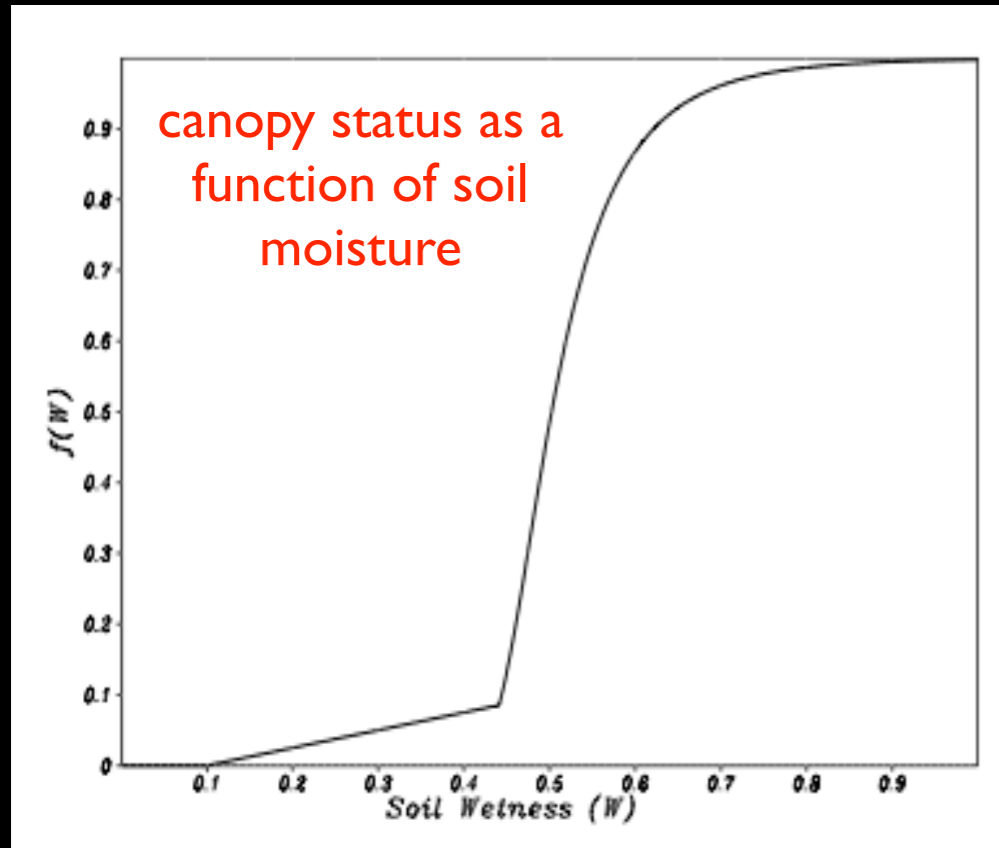


LMWG meeting, NCAR, 2-4 Mar 2015

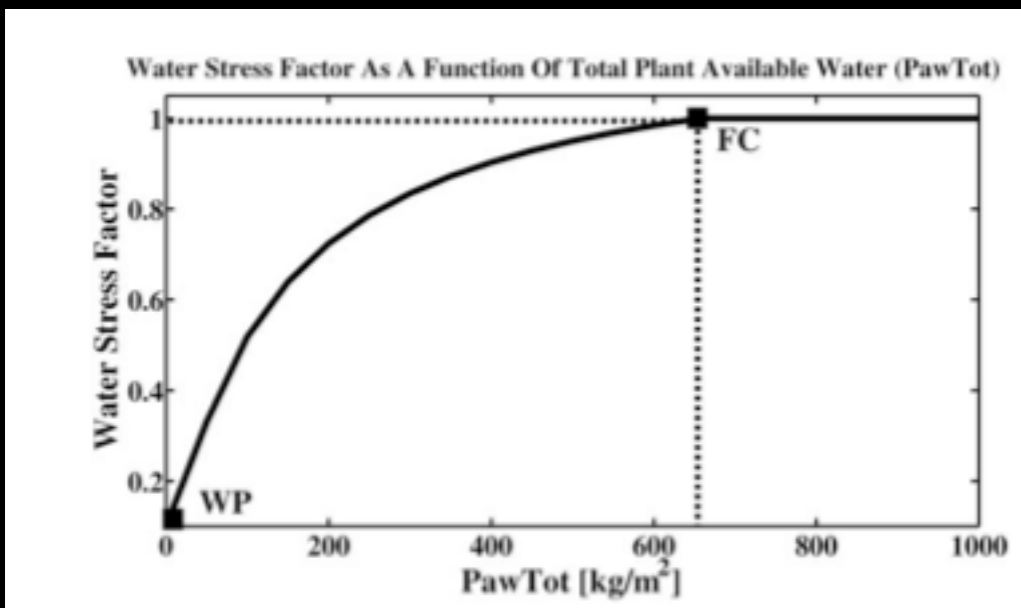
Soil Moisture Heterogeneity



Plant Response to Soil Moisture

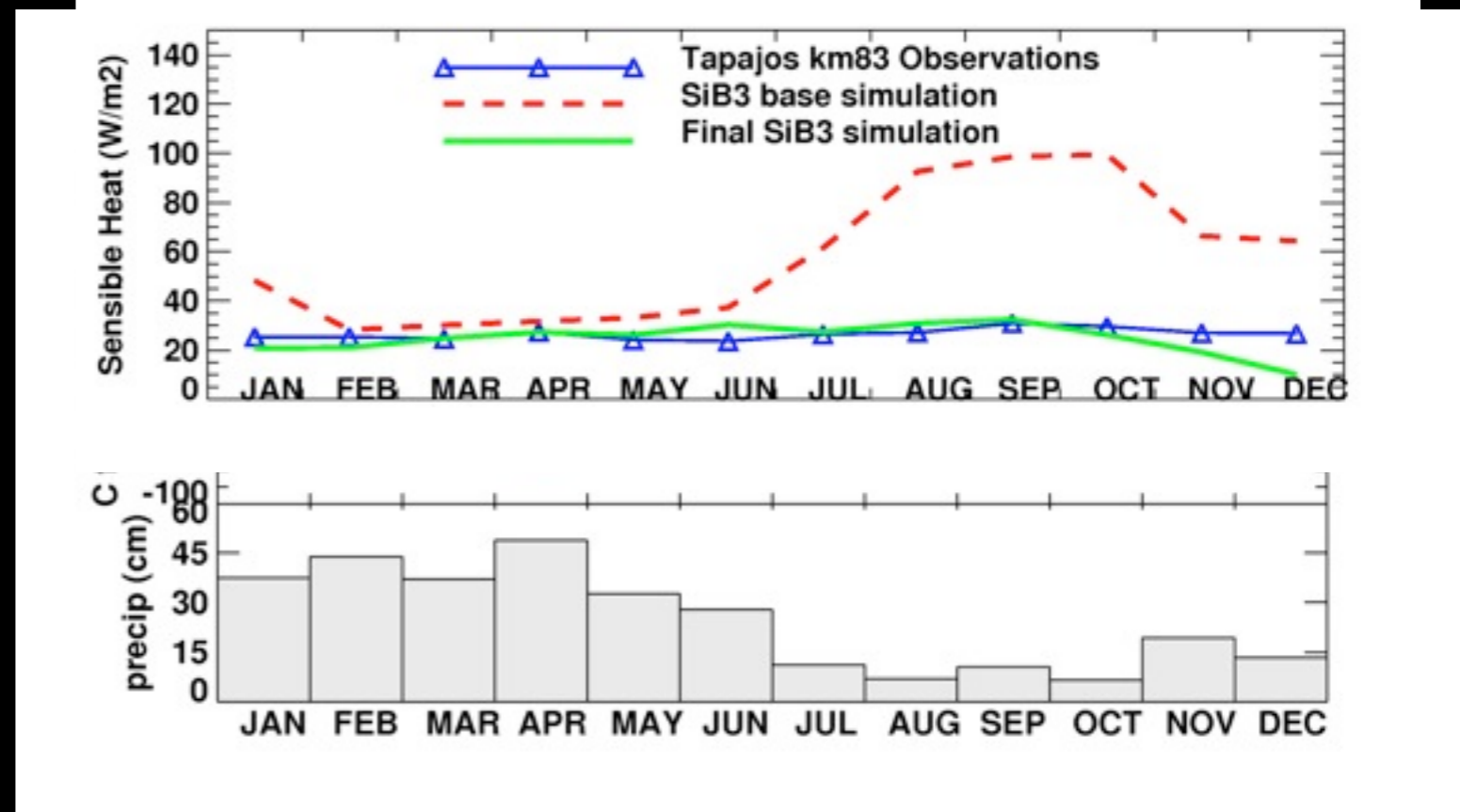
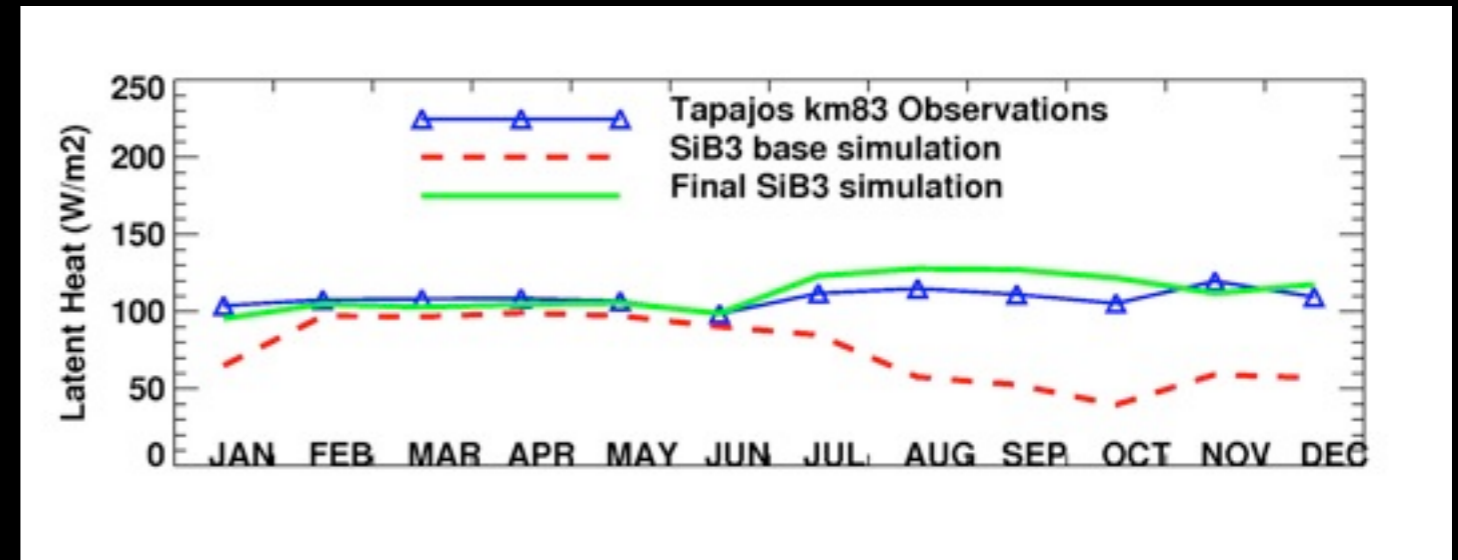


Data from FIFE (Coello et al., 1998; Sellers et al., 2007)



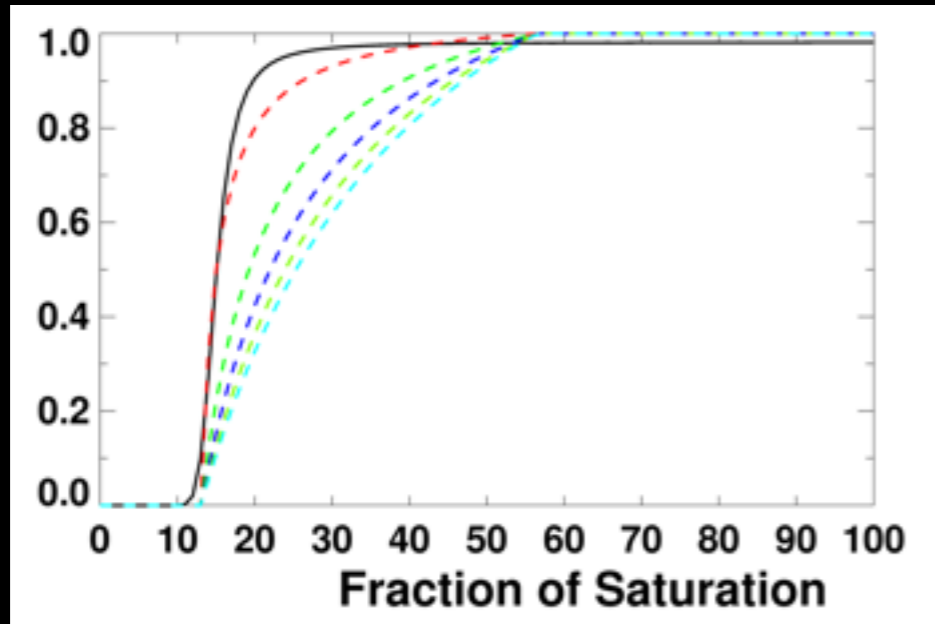
Parameterized evaporation control:
Baker et al. (2008), Medina et al. (2014)

Baker et al. (2008)



The problem with doing it this way

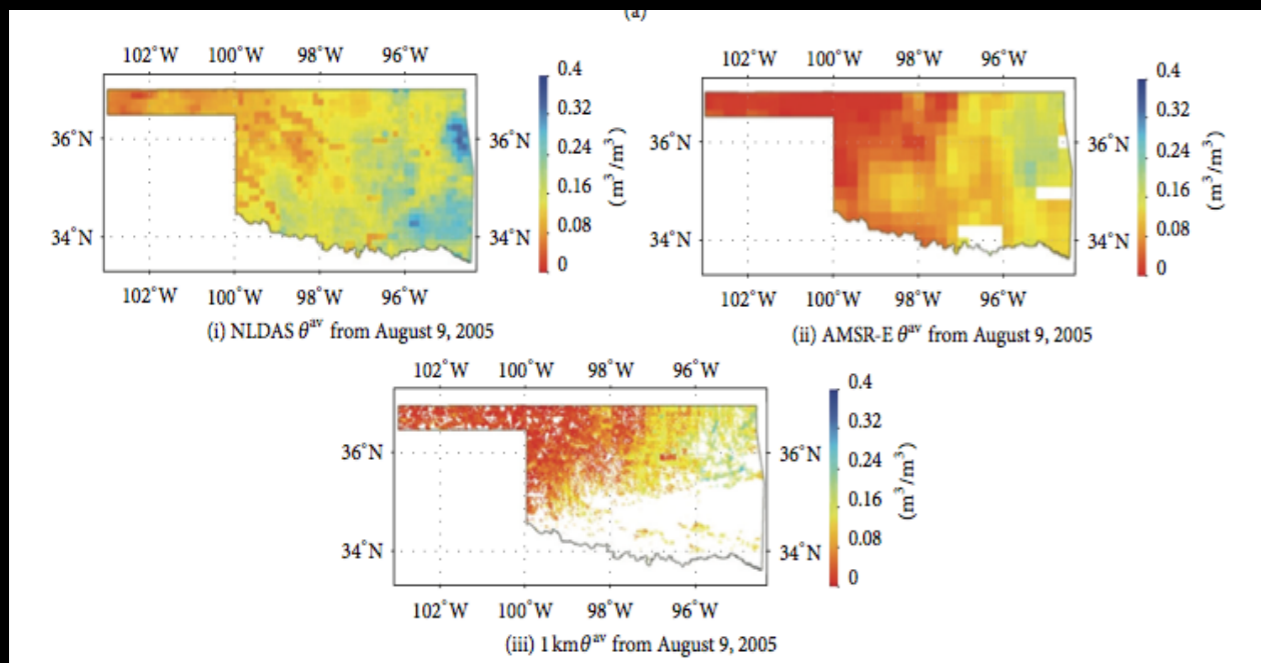
$f(w)$



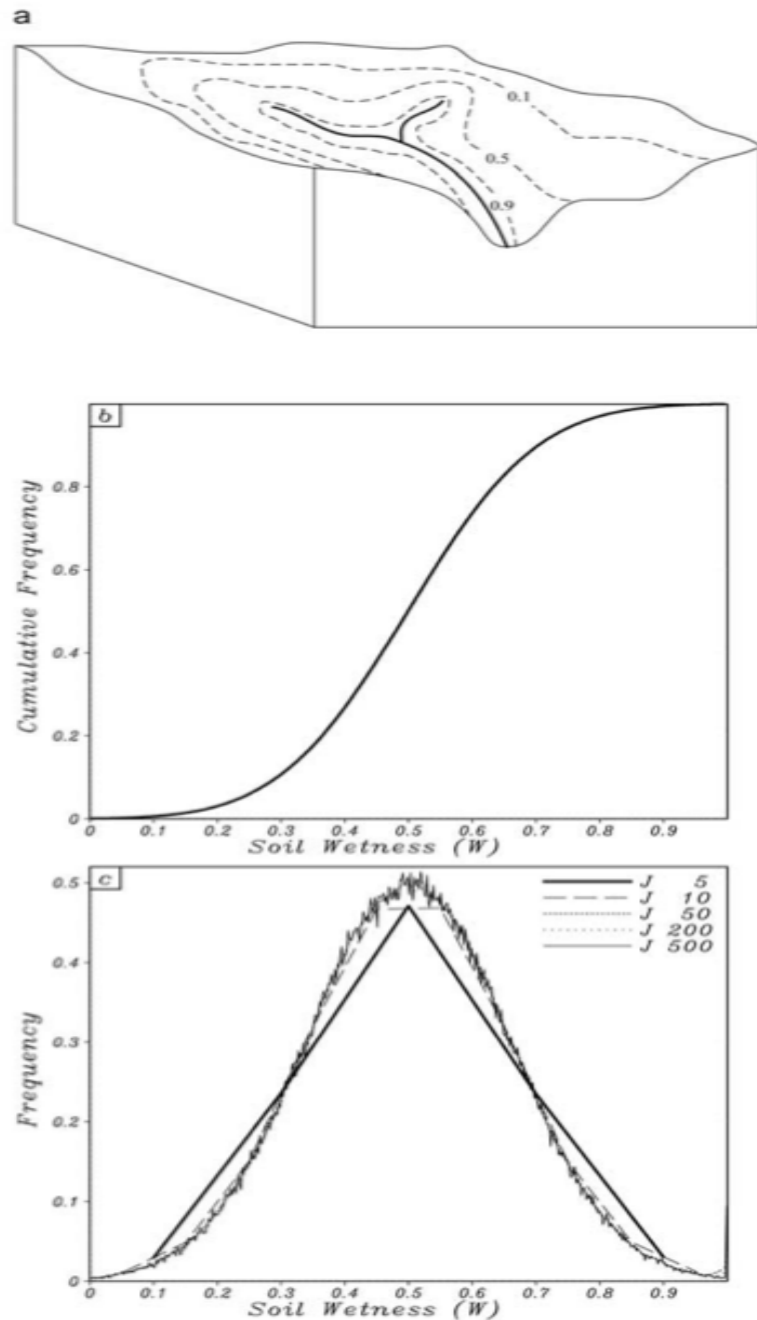
$$E = E_p f(W)$$

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

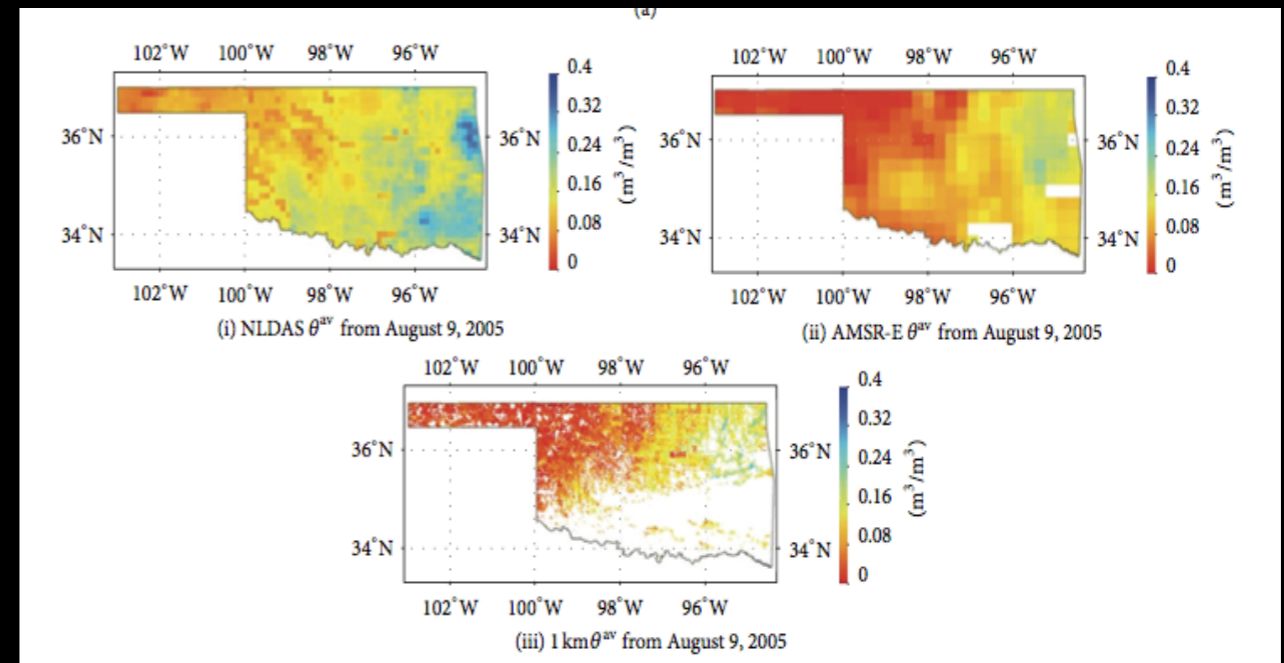
$$\overline{f(x)} \neq f(\bar{x})$$



A New Approach: Wetness Bins



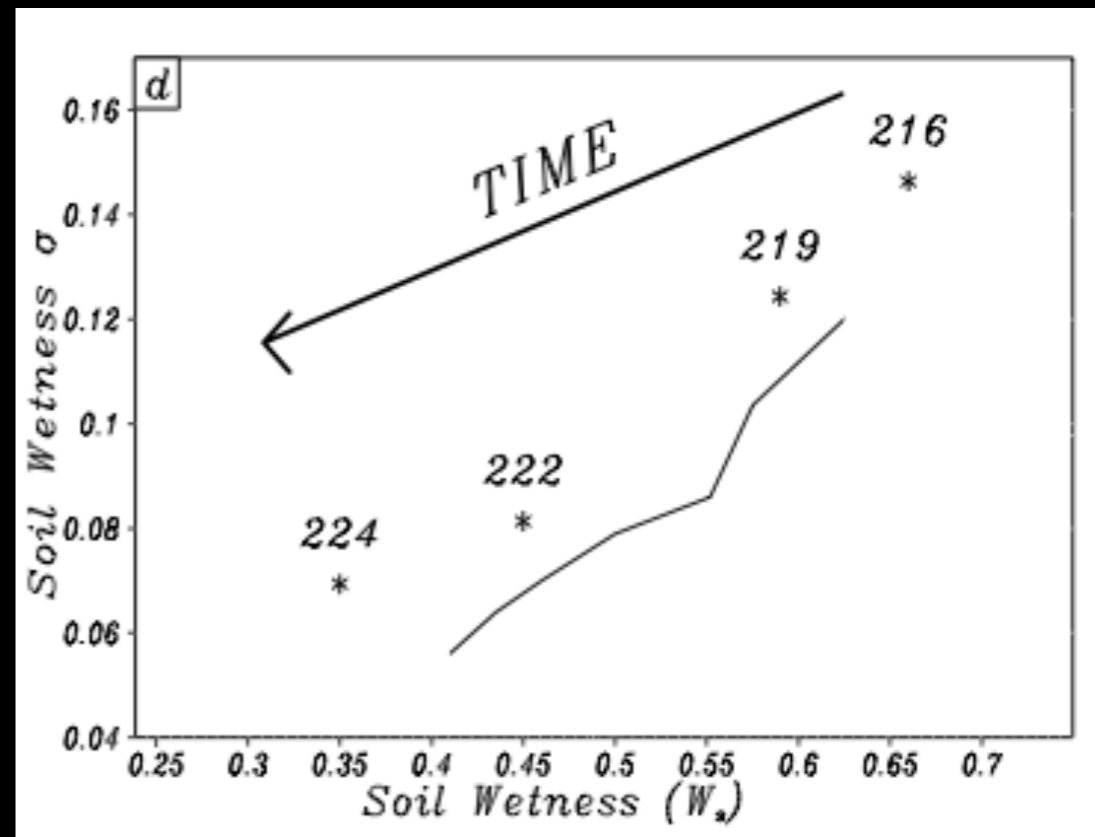
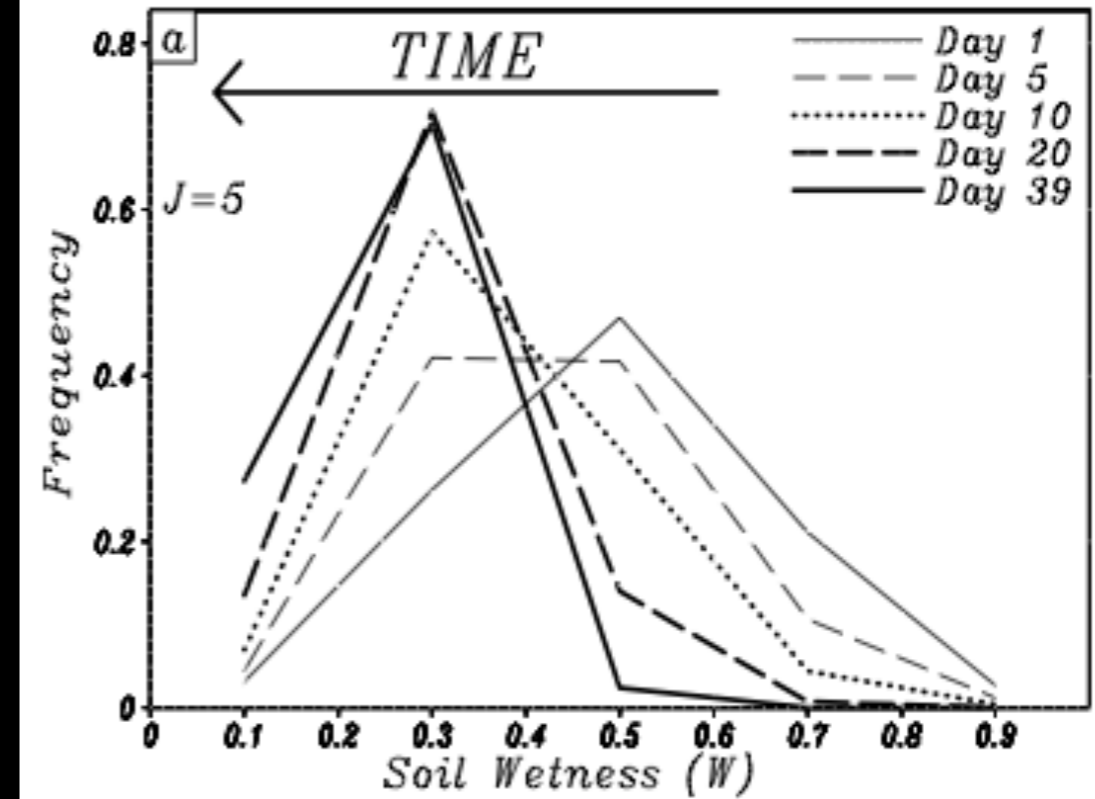
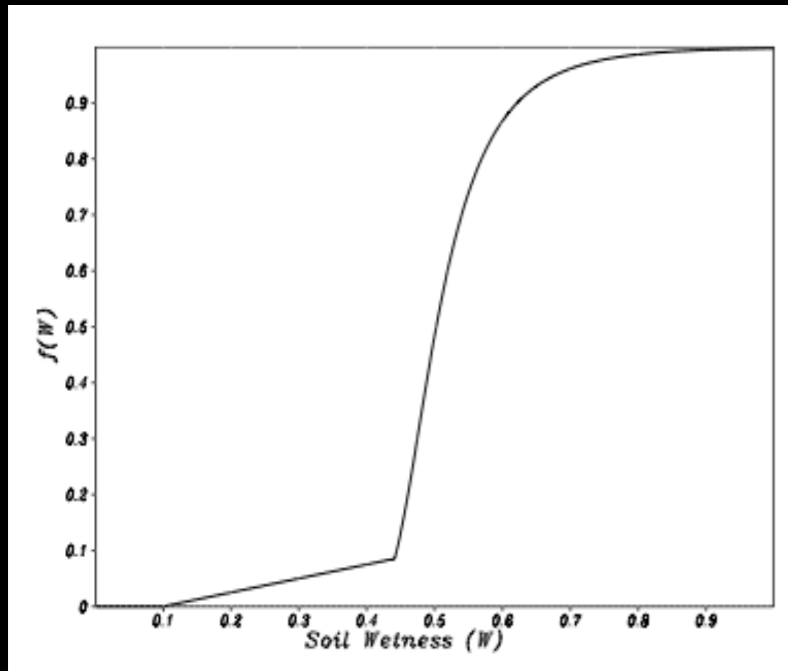
Several ways to
consider wetness: from
Sellers et al. (2007)



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

Toy Model

(Sellers et al., 2007)



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

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

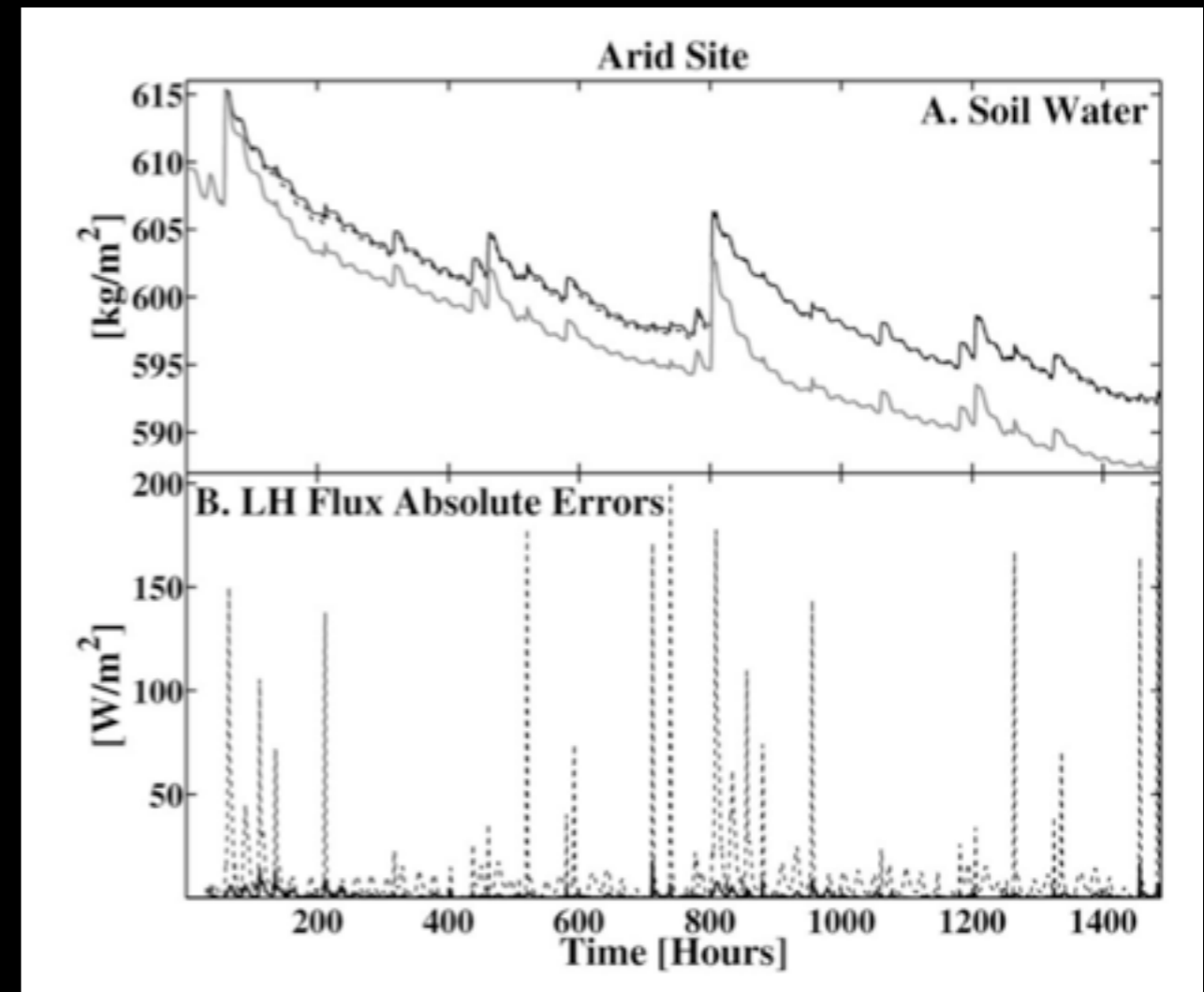
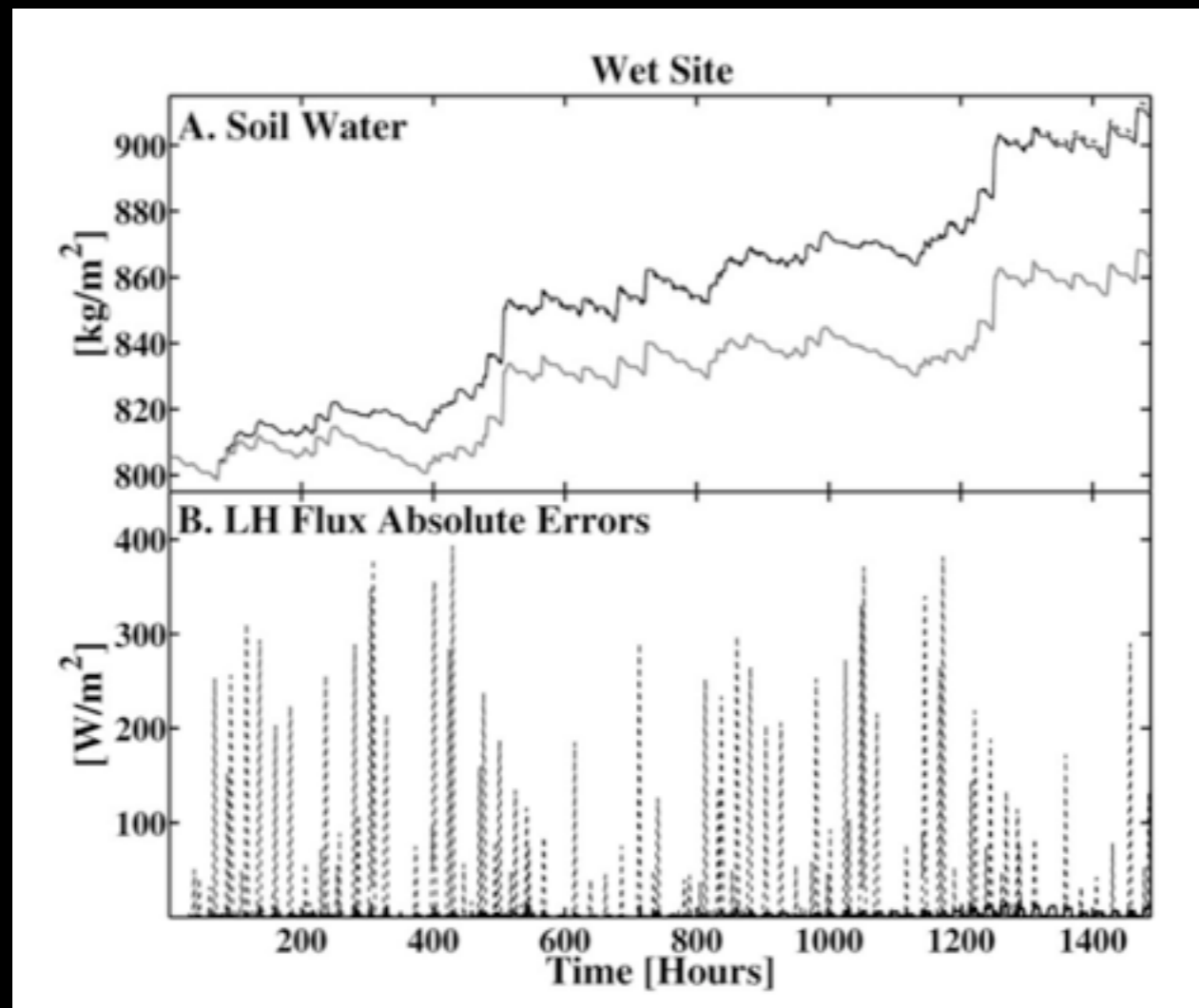
From the Toy to the Full Model

- Medina et al., JAMES, 2014

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

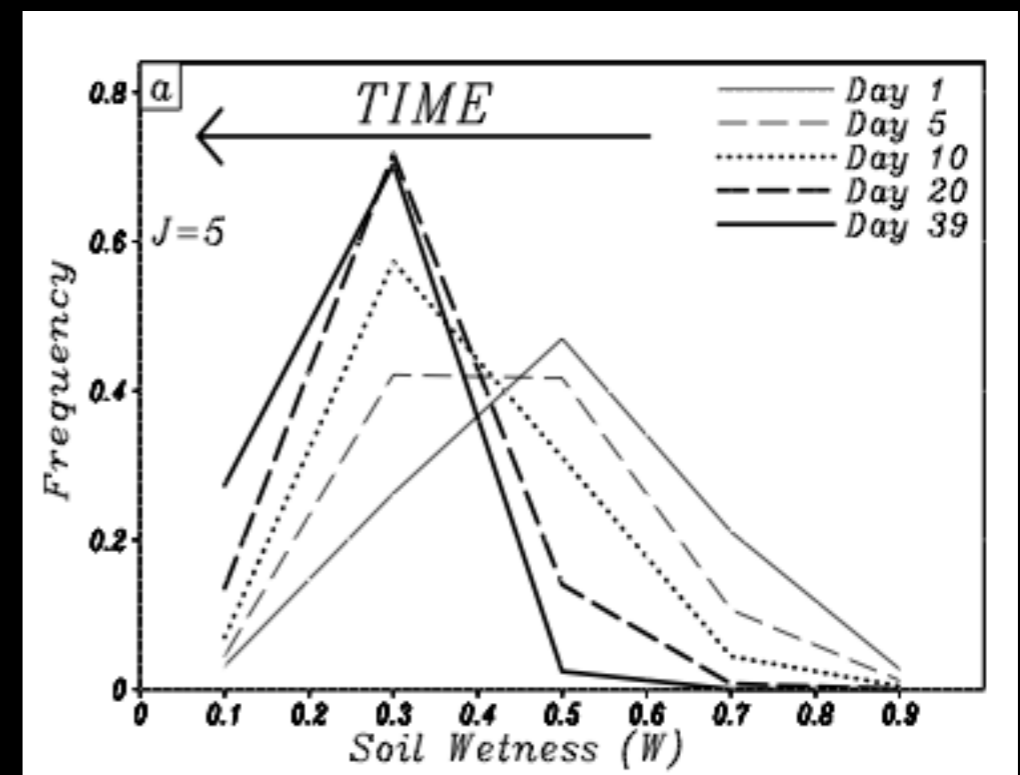
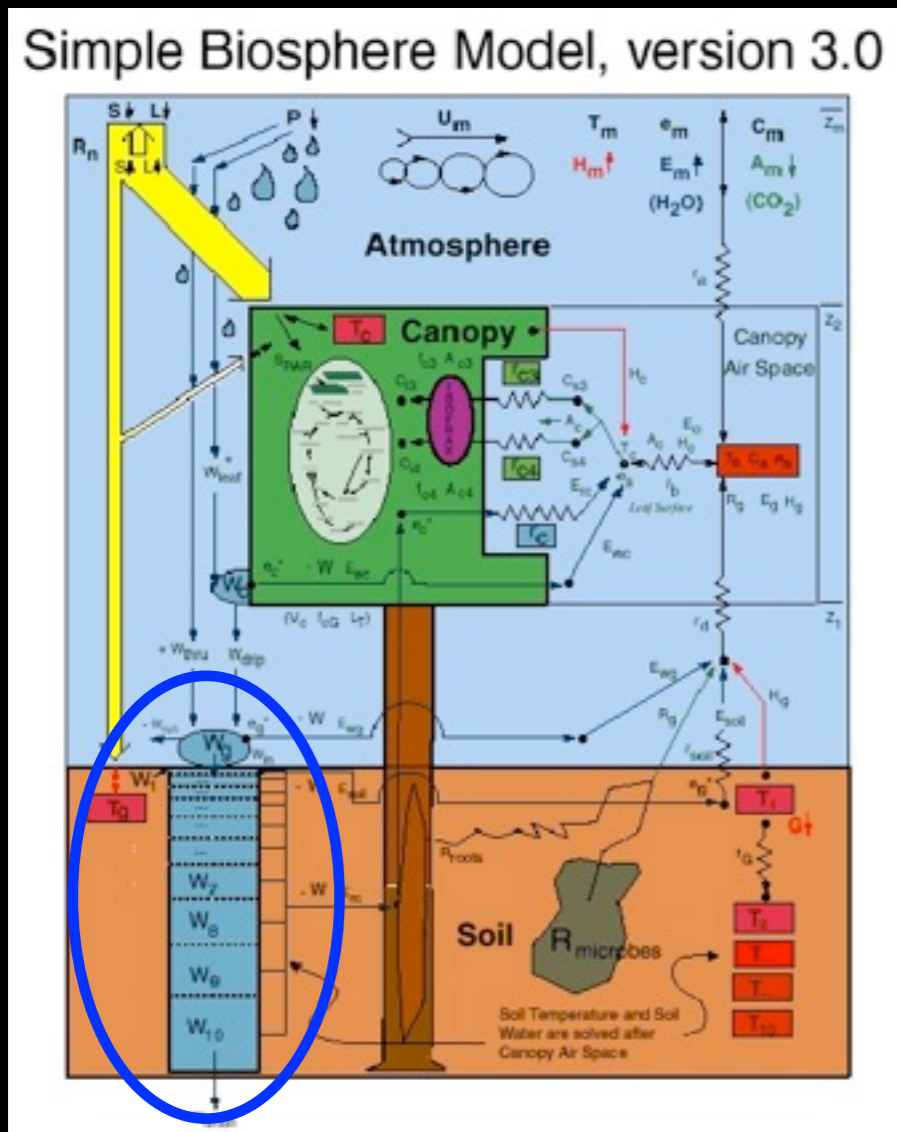
gray = $f(\bar{x})$

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

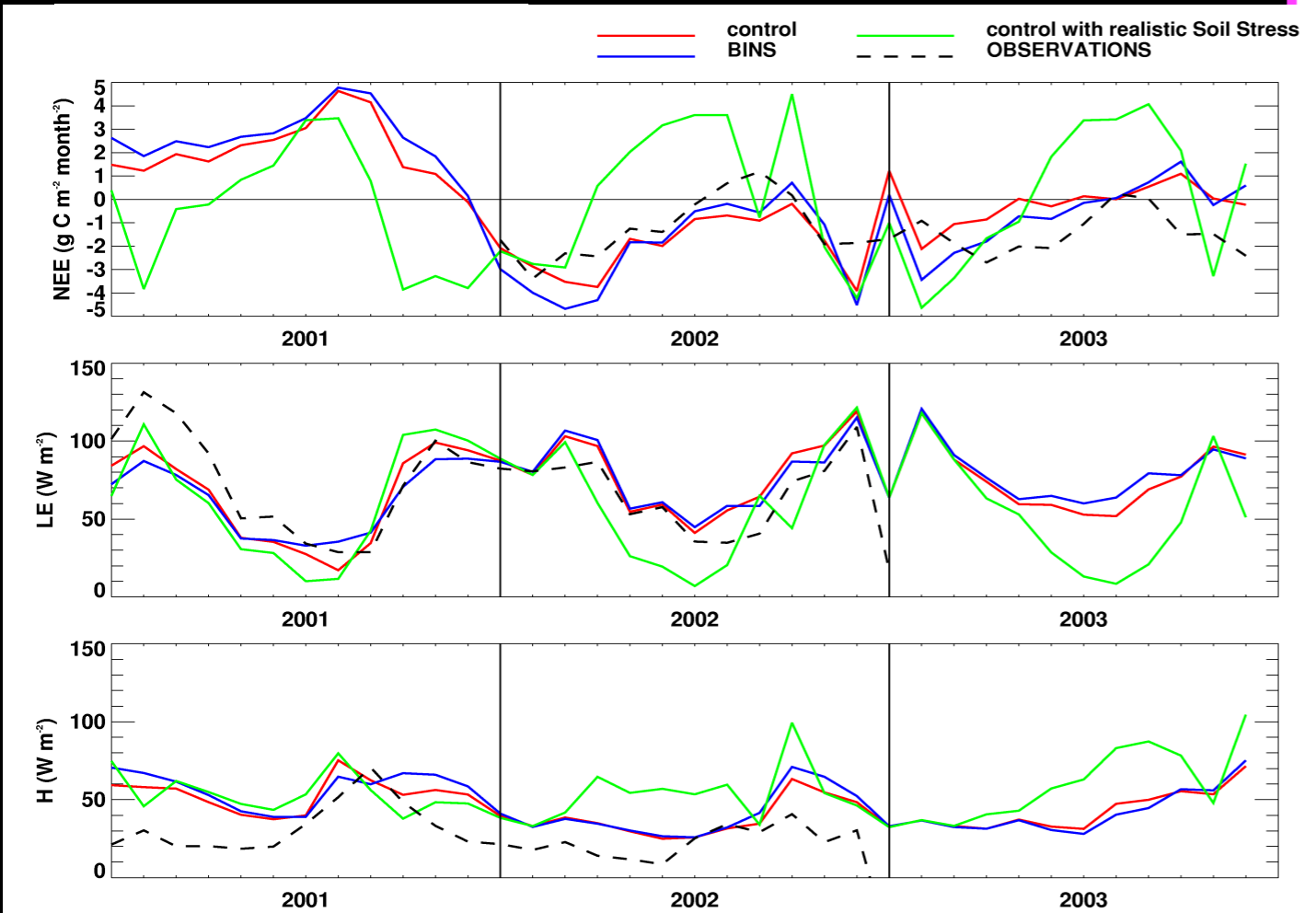
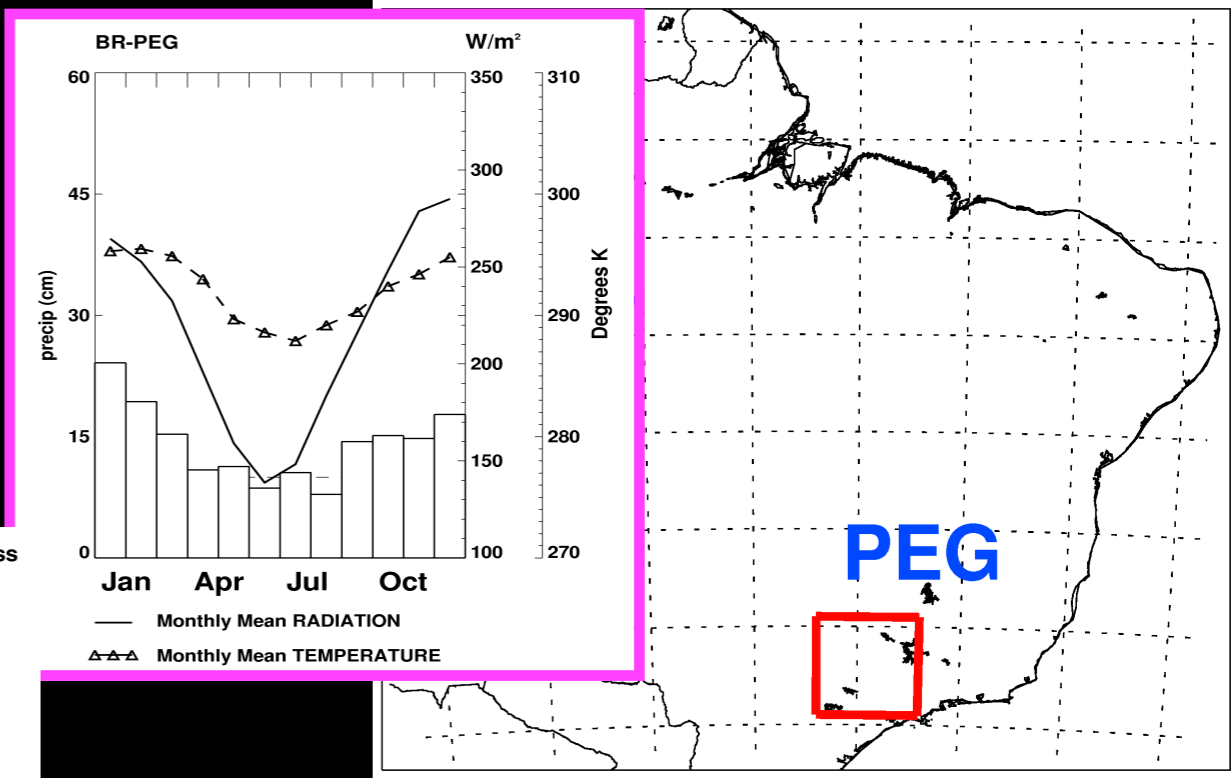


1. Precipitation onto canopy (throughfall, drainage)
2. Surface interception/runoff/infiltration
3. Update bins/z-column
4. Determine stress $f(W)$
5. Calculate Energy/Moisture exchange
6. Remove water from soil (transpiration)
7. Update bins/z-column

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

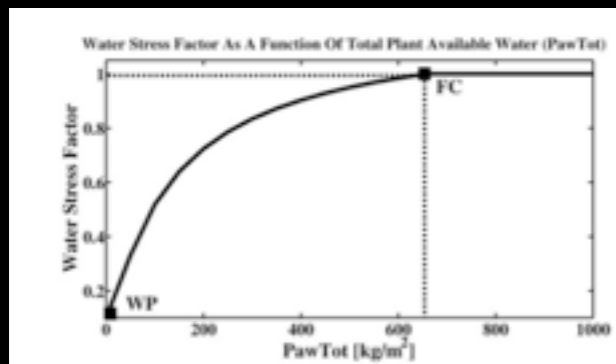
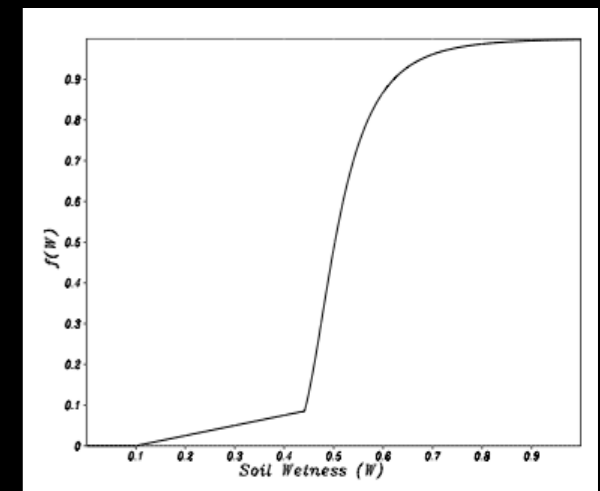
$$\sum_{j=1}^{nbins} W_j a_j = \sum_{i=1}^{nsoil} W_i, z_i$$

Results: A Site That Works (PEG)



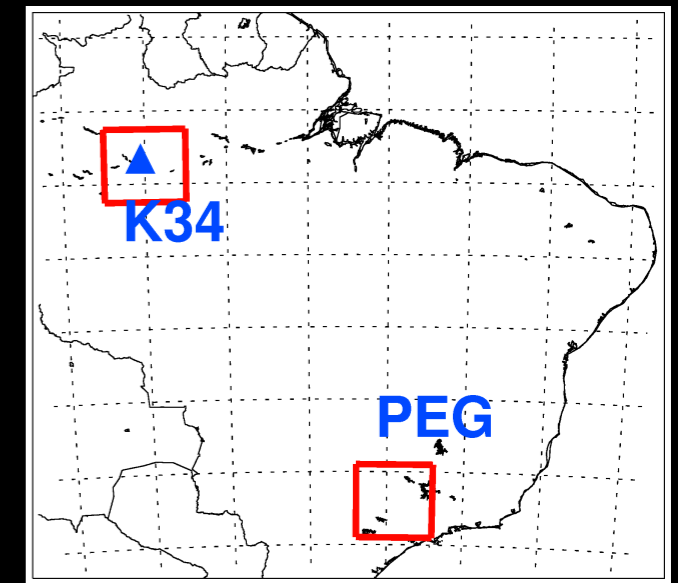
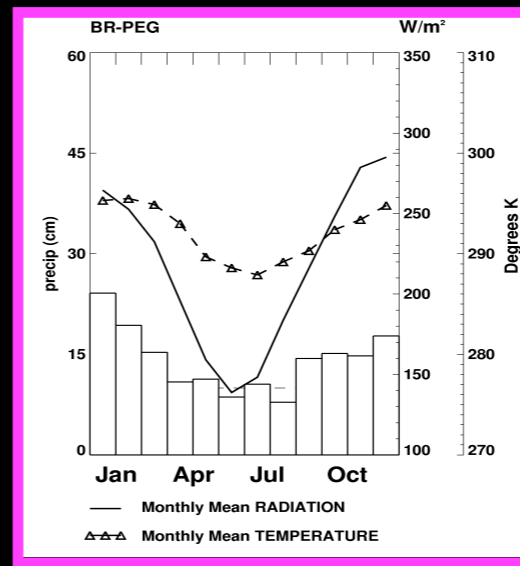
1. Control: Baker et al. (2013), 'adjusted' SW stress
2. Control w/ realistic stress: 'Wrong answer, right reason'
3. BINS

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

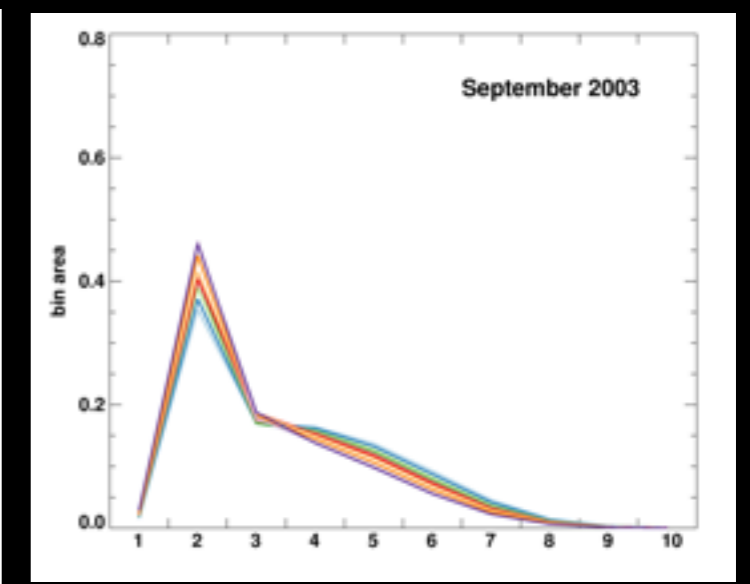
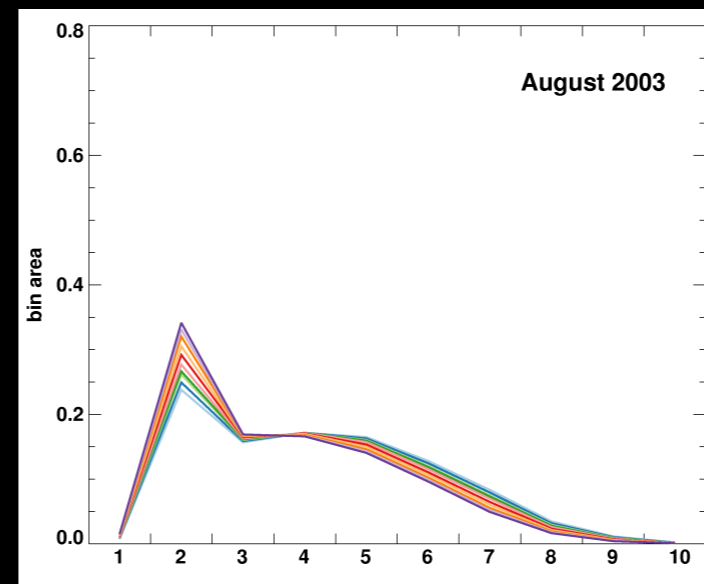
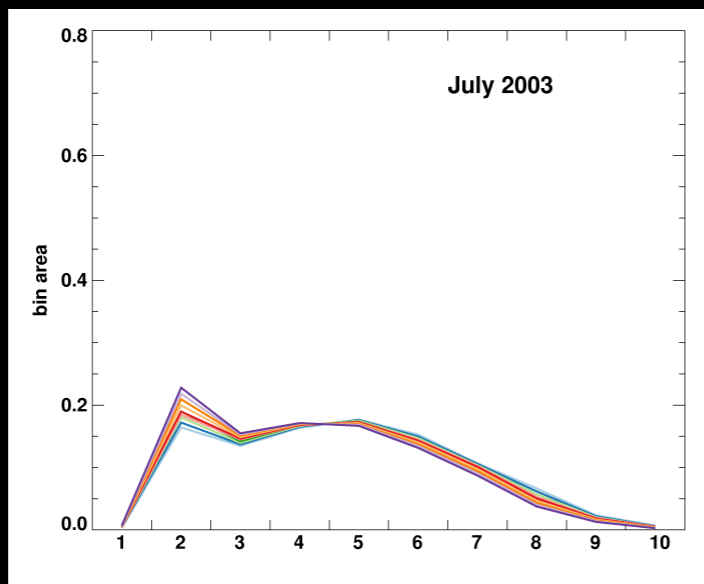


$f(w)$ for the control run (red)

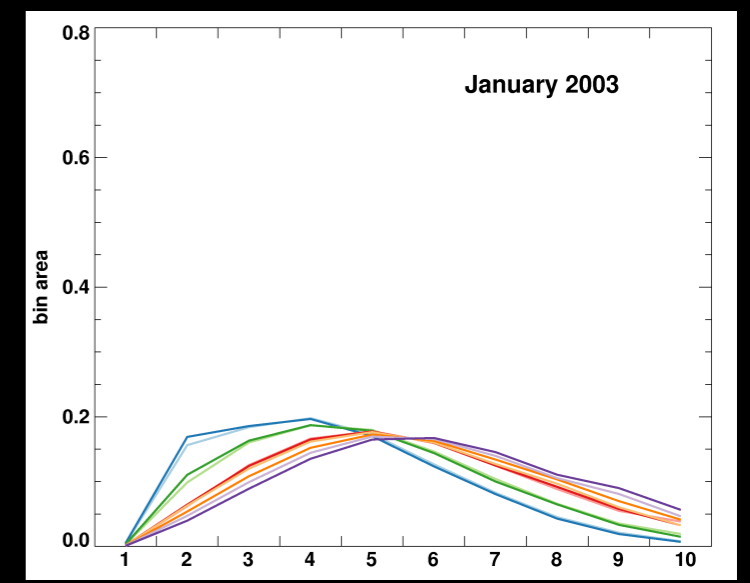
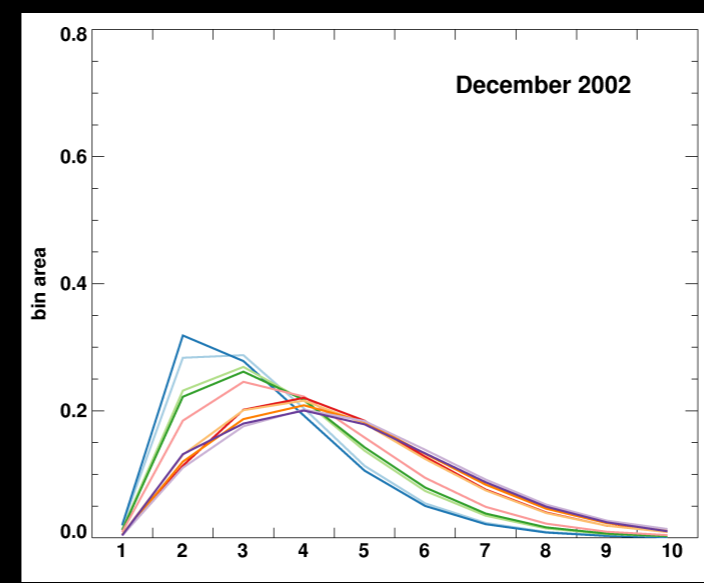
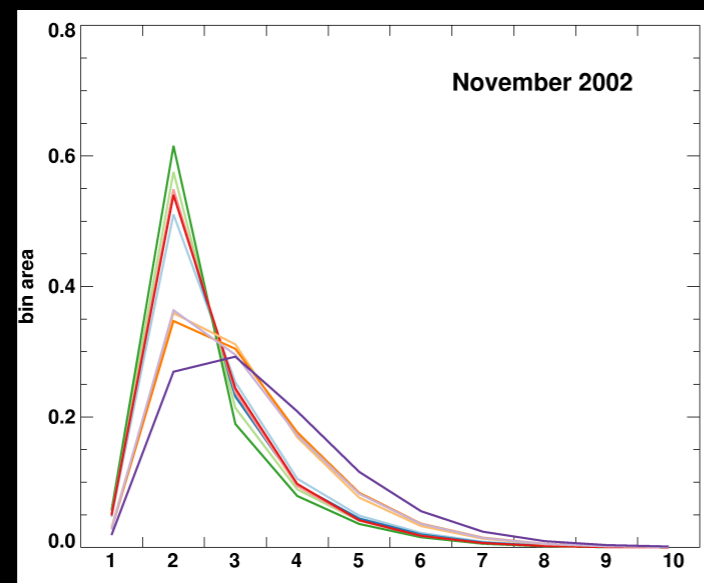
Results: A Site That Works (PEG)



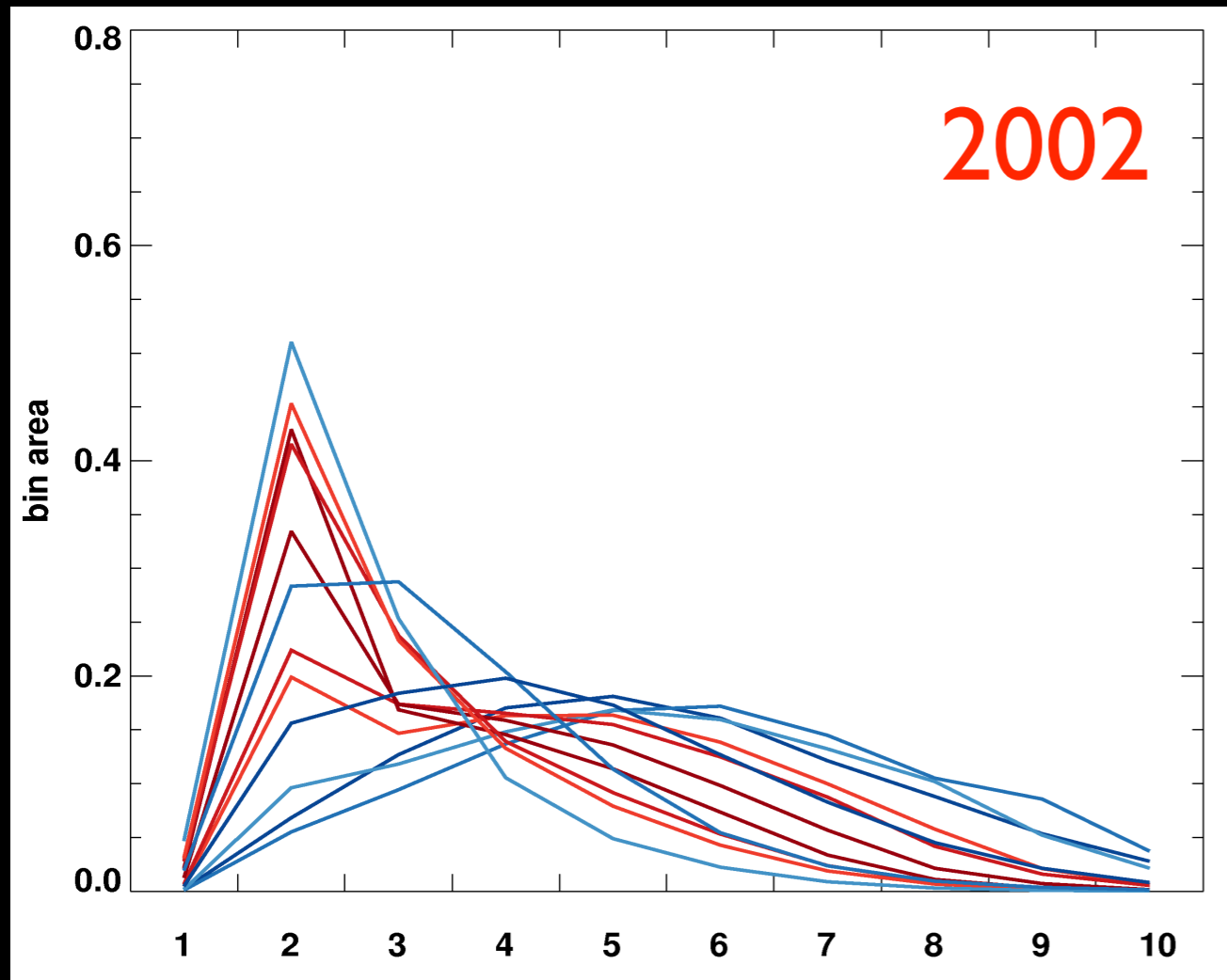
Drying



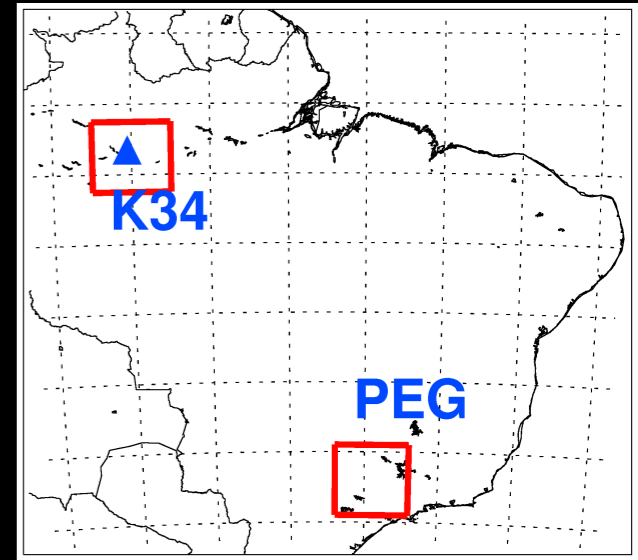
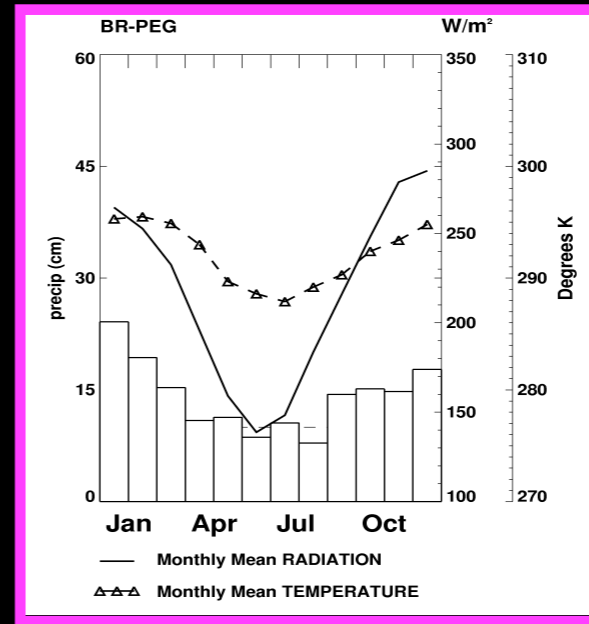
Moistening



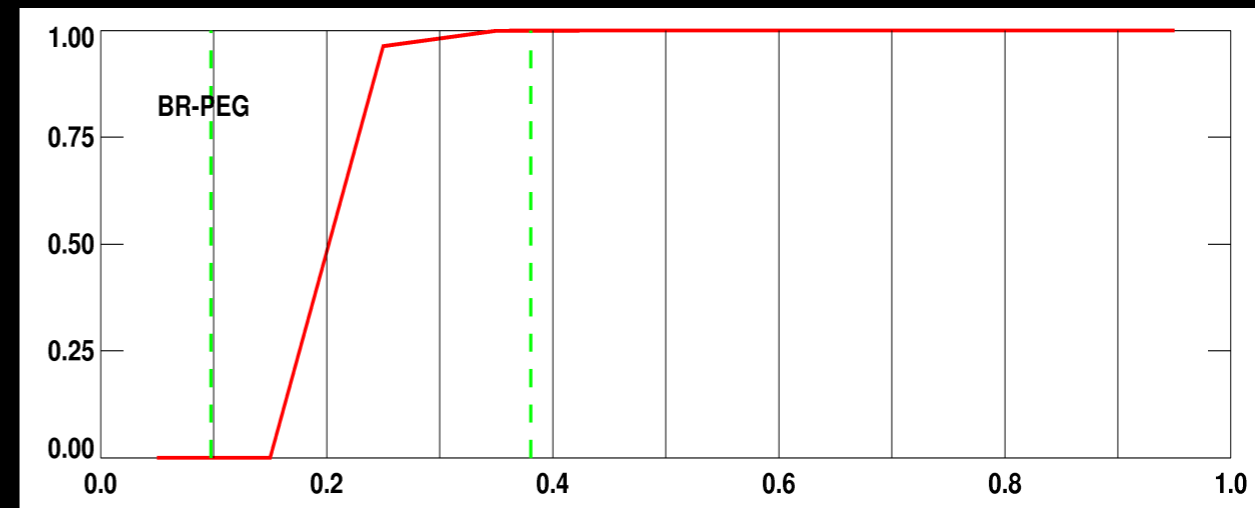
Results: A Site That Works



bin number

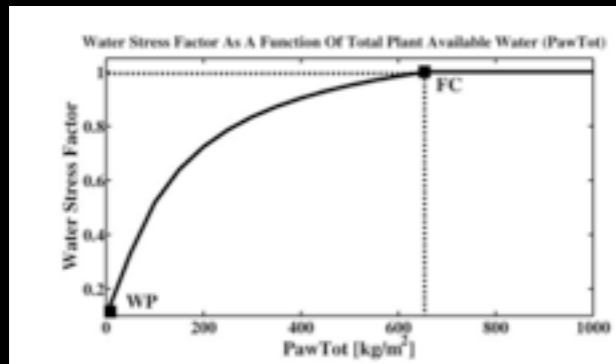
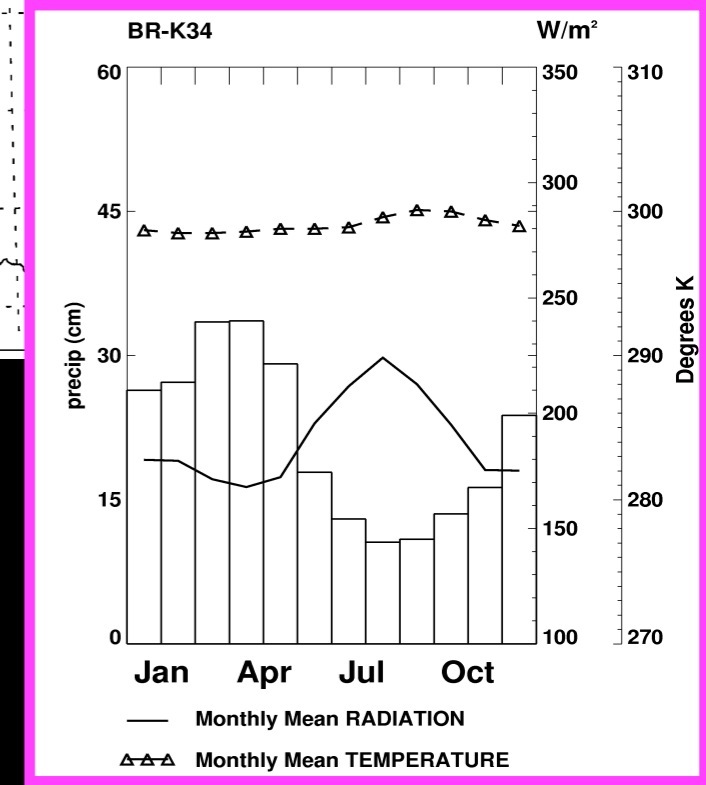
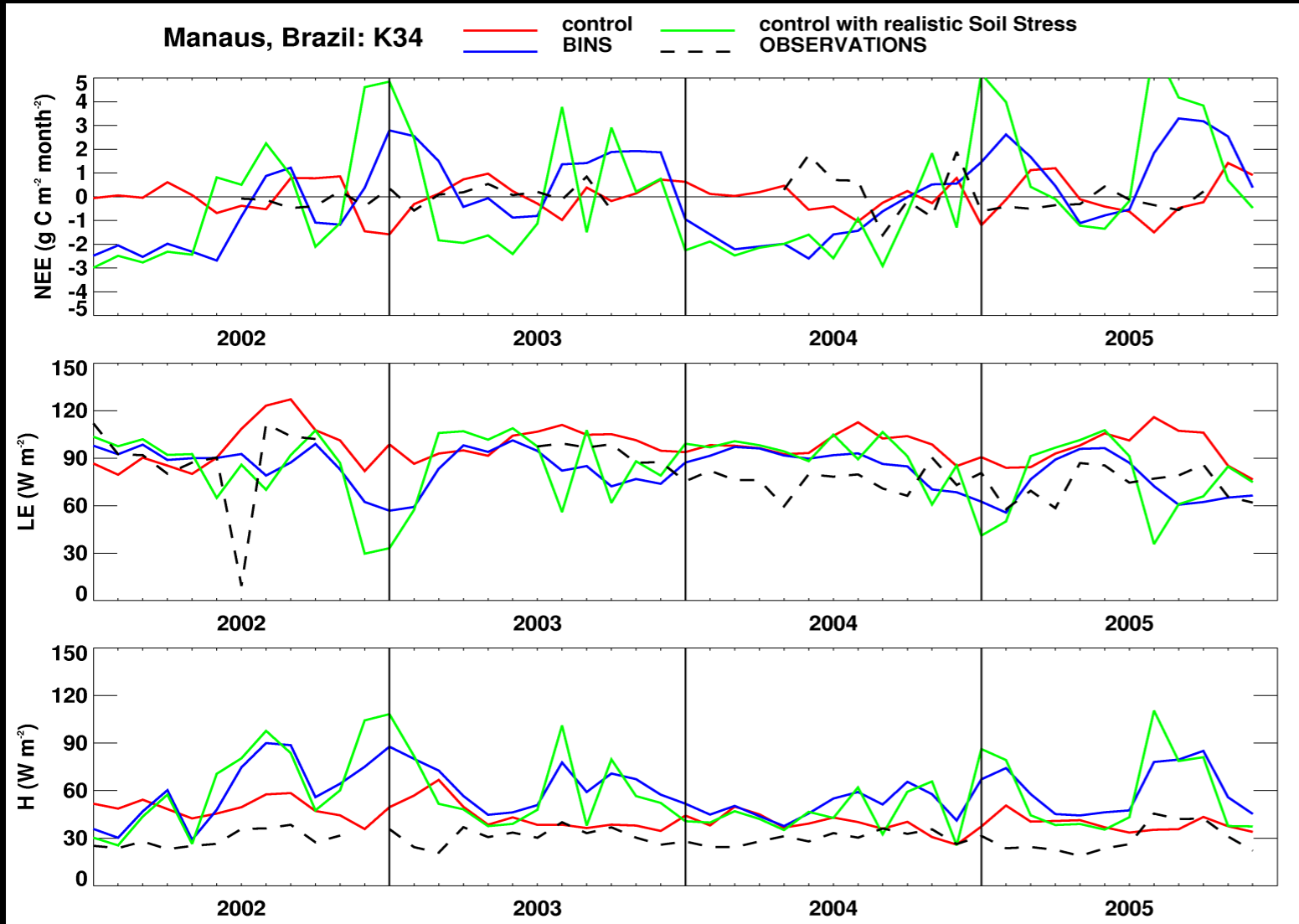
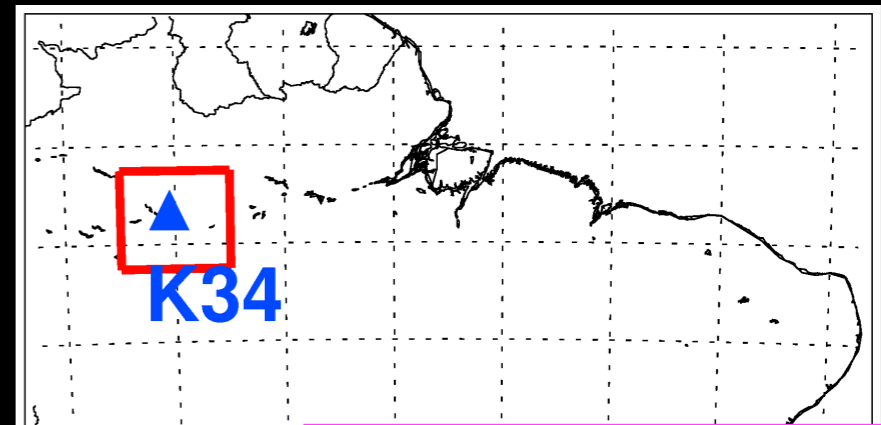


evaporation control $f(w)$



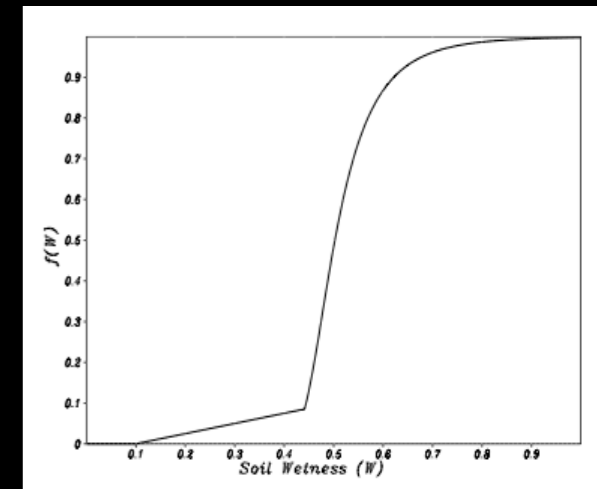
fraction of saturation/bin

Results: A Site That Doesn't Work

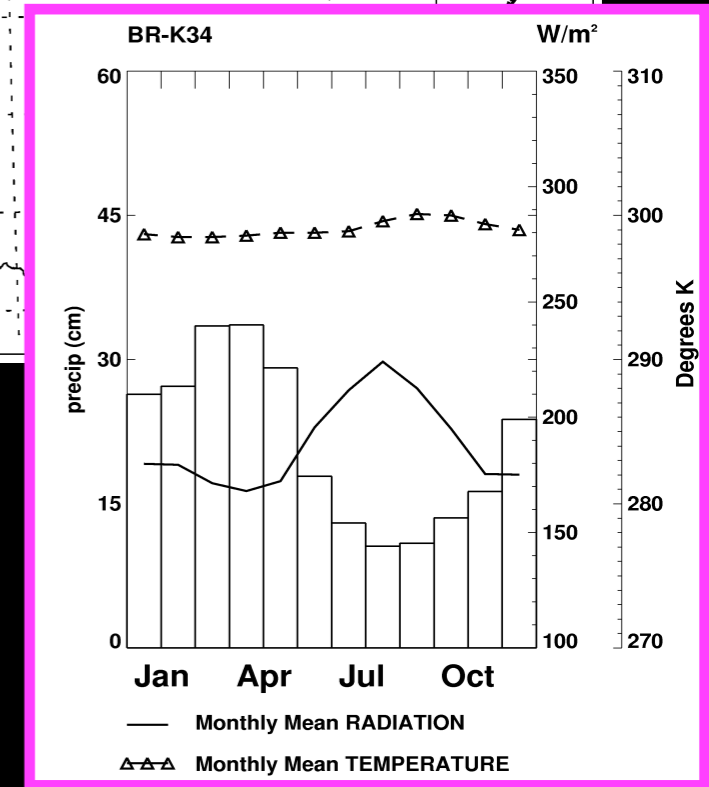
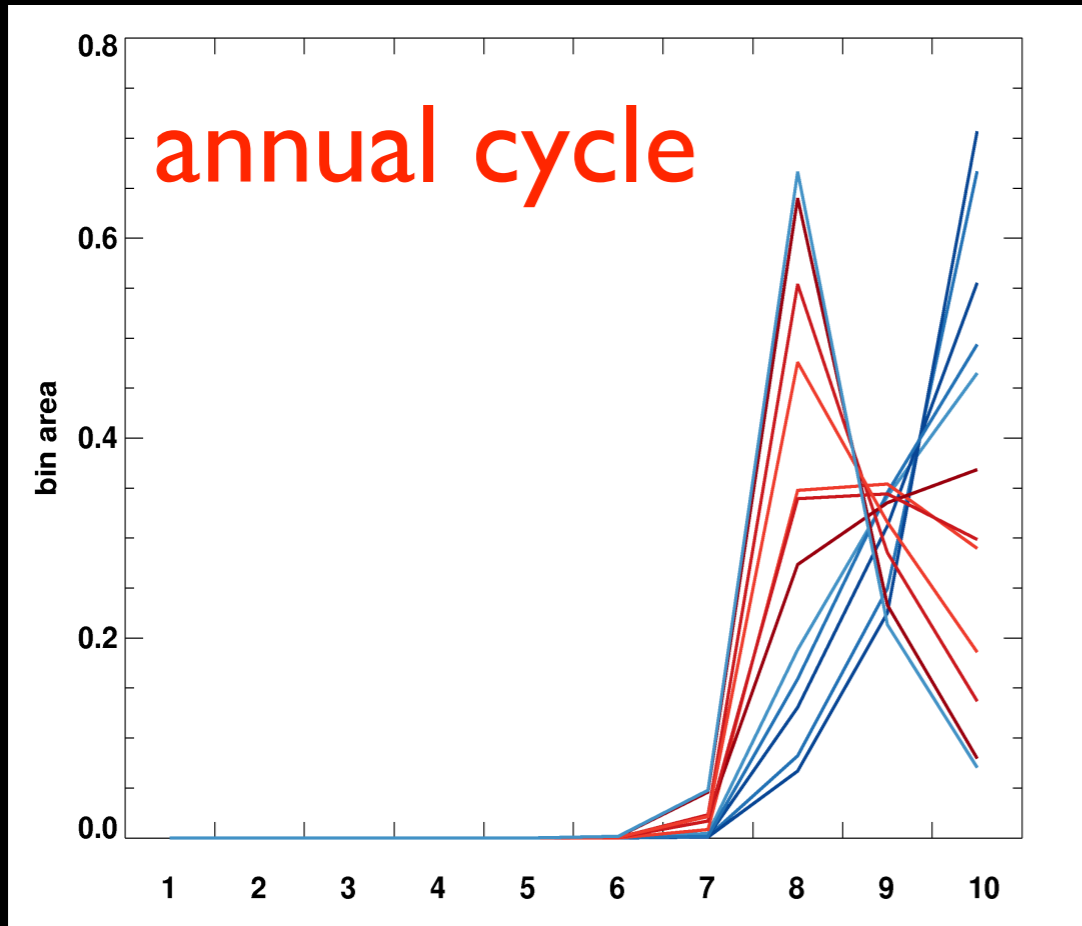
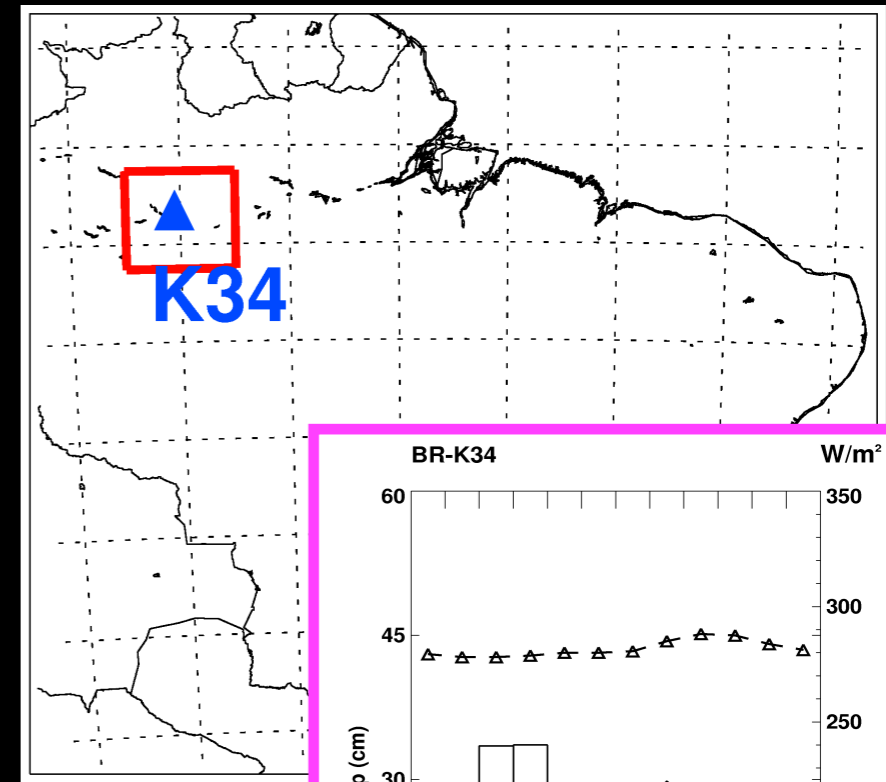


$f(w)$ for the control run (red)

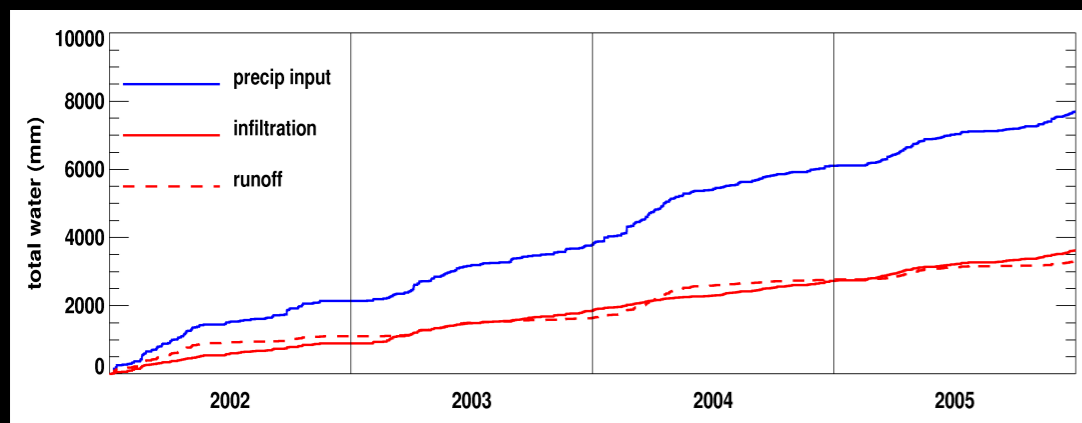
$f(w)$ for 'control w/ realistic' (green) and bin (blue) runs



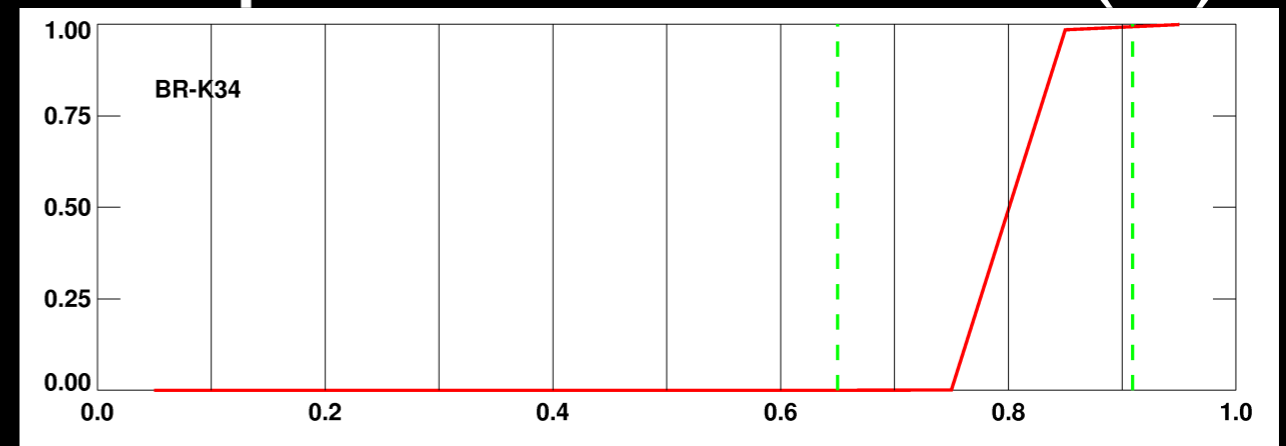
Results: A Site That Doesn't Work



infiltration/runoff partition



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?
- How would bins interact with subgrid tiling of PFTs?

QUESTIONS?



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Deployed NGE- Arctic Tram
Stan Wullschlegel¹
Laboratory

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) -> through fall drainage -> surface evaporation/interflow -> base flow
2. Update soil (Jaffar) -> determine stress (Eq 1, Eq 2)
3. calculate area mean SFC -> Net Radiation -> photosynthesis/transpiration -> LE, H
4. calculate water -> Net Evaporation -> using photosynthesis -> fluxes
5. Update time -> ET removal

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 energy, water and 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 model and its performance is being evaluated. The approach is being used to calculate fluxes of energy, water and carbon fluxes.

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

Towards the spatial...
Rieke W. ...
Objectives
Methodology and Results
US-77 447 in full tower
Measurement height: 122 m

IAN BAKER
MEMBER

PIERS SELLERS