Parameterizing the FAO-56 Penman-Monteith Equation for Use in a Green Roof Water Balance Model.

Olyssa Starry,
December 5, 2012

I. Urban stream syndrome and greenroofs

II. Greenroof modeling

III. Evapotranspiration

IV. Model testing

V. Future directions

VI. Feedback/questions

I. Urban Stream syndrome

Walsh et al. 2005

- Decreased infiltration, "Flashy" hydrology
  (Konrad and Booth 2002)
- Changes in stream chemistry/ecology
  (Paul and Meyer 2001)
- Changes in stream channel
  (Dunne and Leopold 1978)

Antiquated approaches to roofing are toxic!

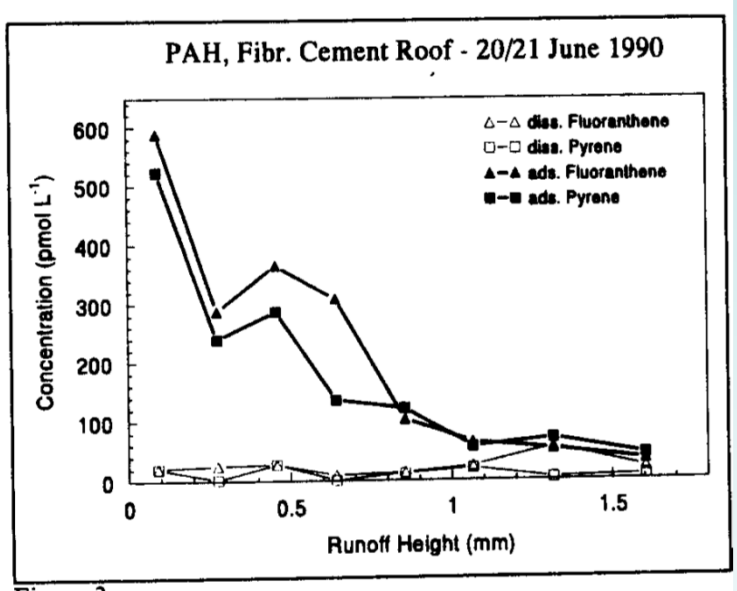
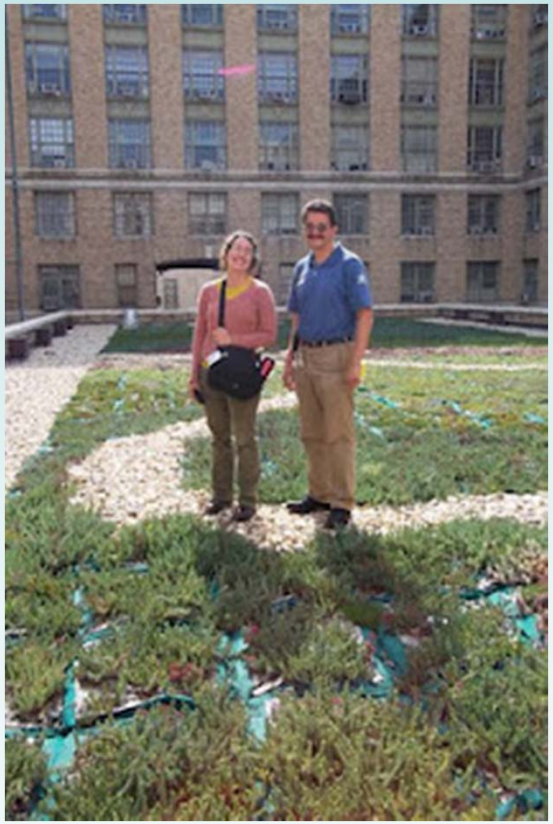


Figure 3

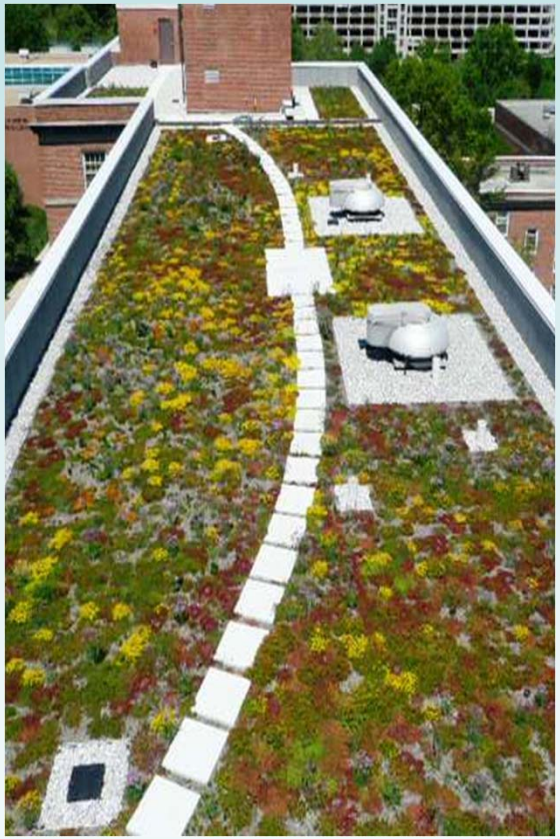
From Foster 1999

II. What are greenroofs?

Modular vs Roll-out vs Single course:



http://globegazette.com/news/central-park-dentistry-gets-green-roof/article_3da31982-e3e0-11e0-9253-001cc4c03286.html



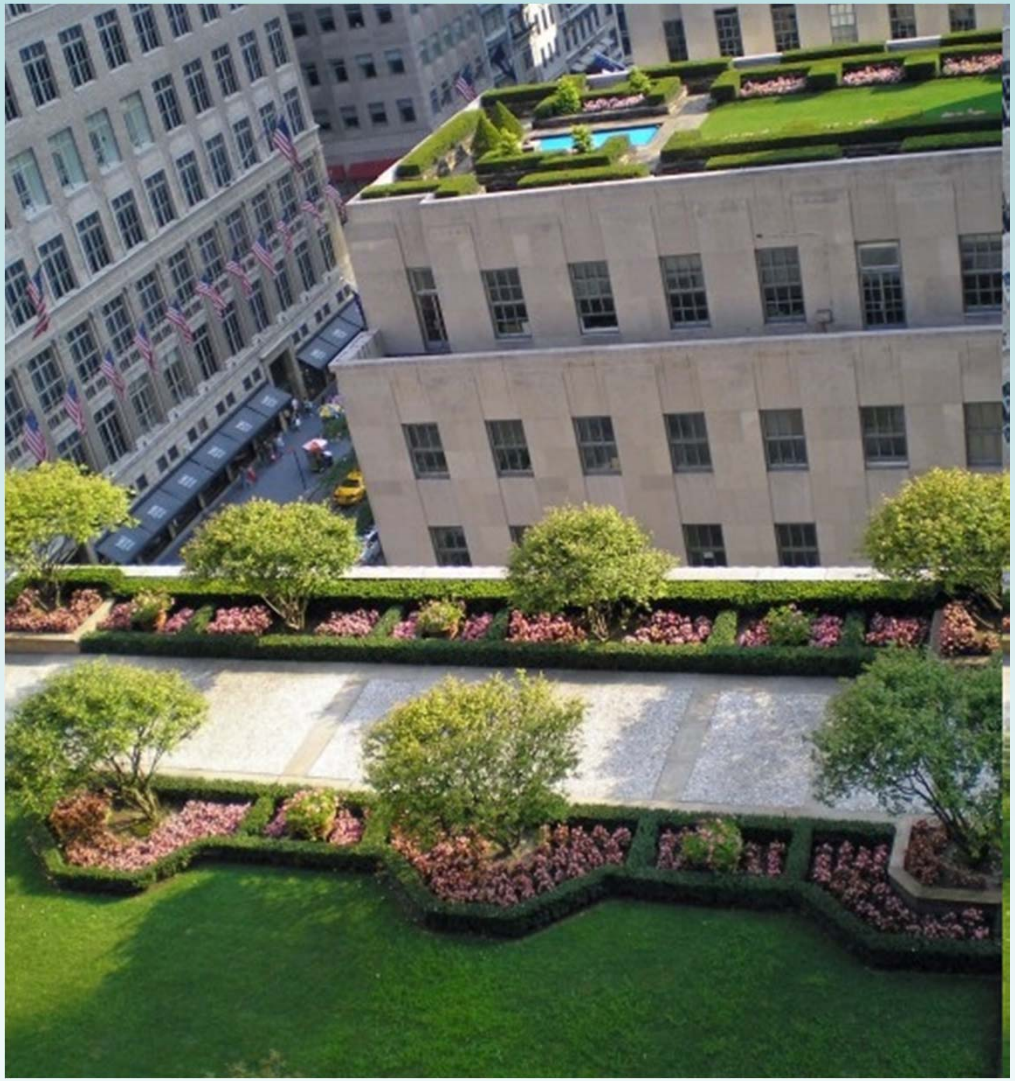
http://www.princetonreview.com/green-honor-roll.aspx

Waldspirale

Christa Reuter Kunsthaus Wien

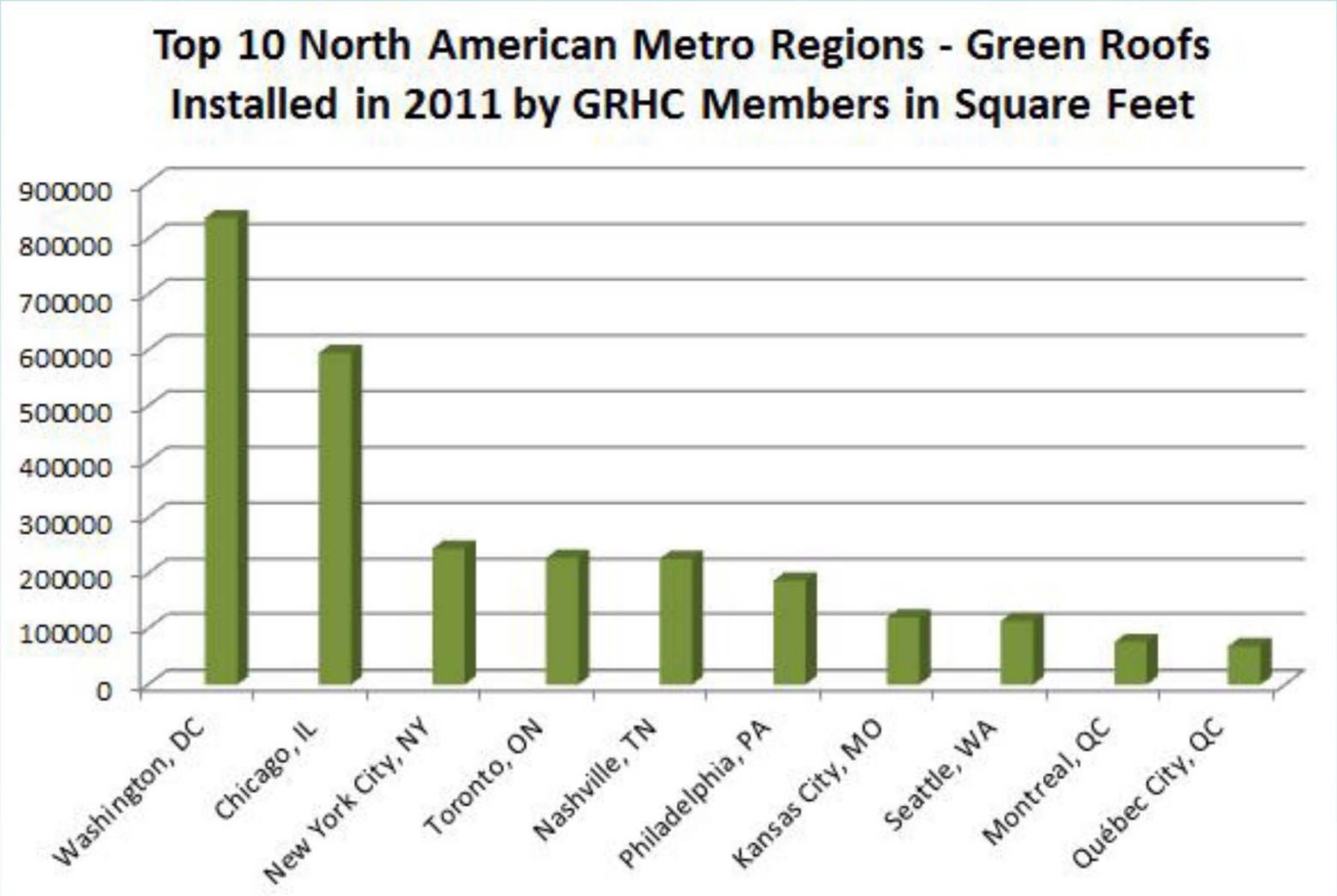
Rockefeller Center

(1936)



http://urbangreens.tumblr.com/

Greenroofs are becoming increasingly common



Greenroofs for Healthy Cities

Greenroof policy: Maryland

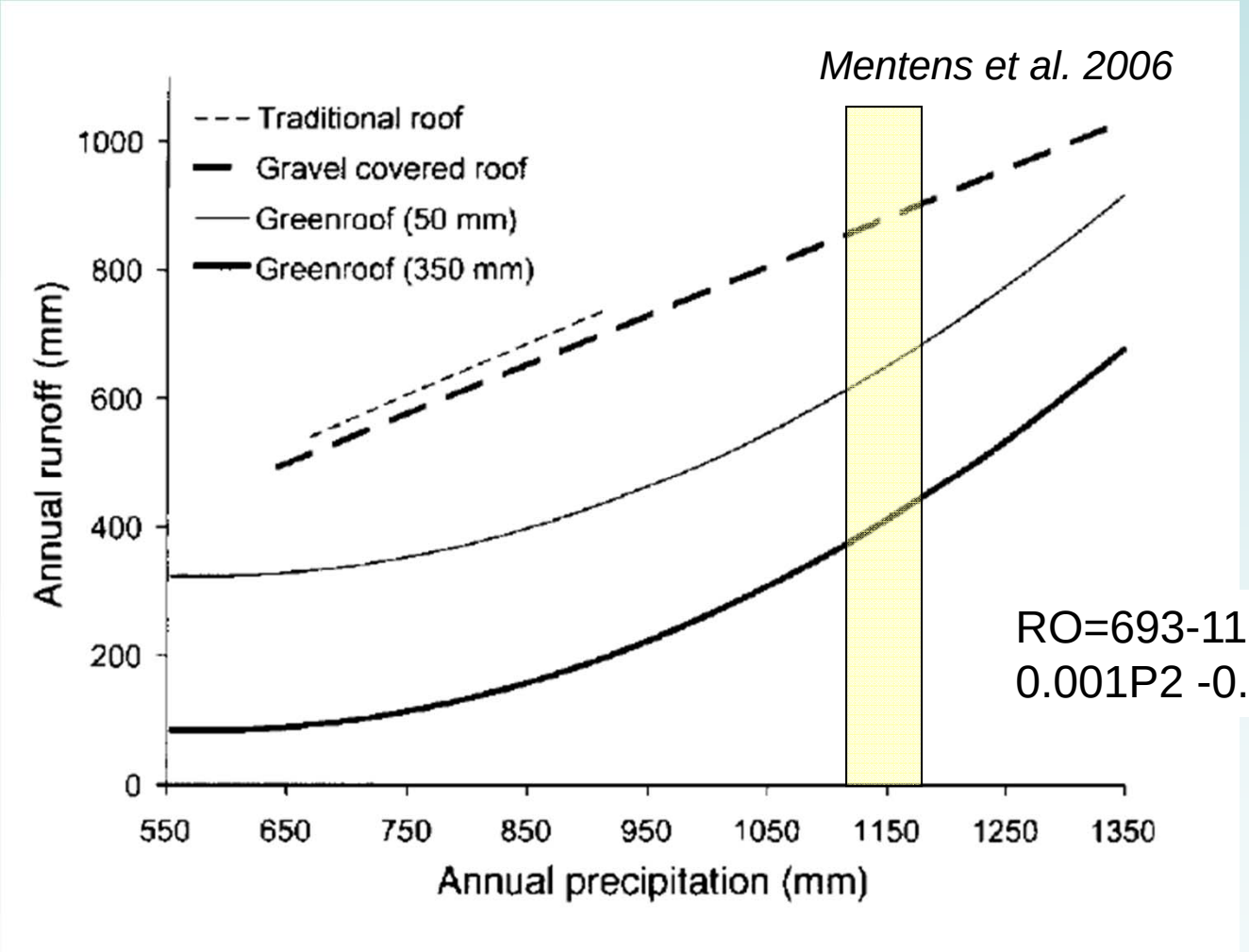
Chapter 5. Environmental Site Design.....

imperviousness may be used during the planni
impervious cover may not be practical. Estima
homogeneity and may reflect NRCS land use/i
2.2a in TR-55, USDA-NRCS, 1986) where ap
(%I) may be calculated from measurements of

- **RCN*:** RCN* is an alternate method to estim
permeable pavements, green roofs) are used to
for the limit of disturbance using the effective
alternative surface.

One year 24-hour storm retention requirement in Maryland for new construction

III. Greenroof models

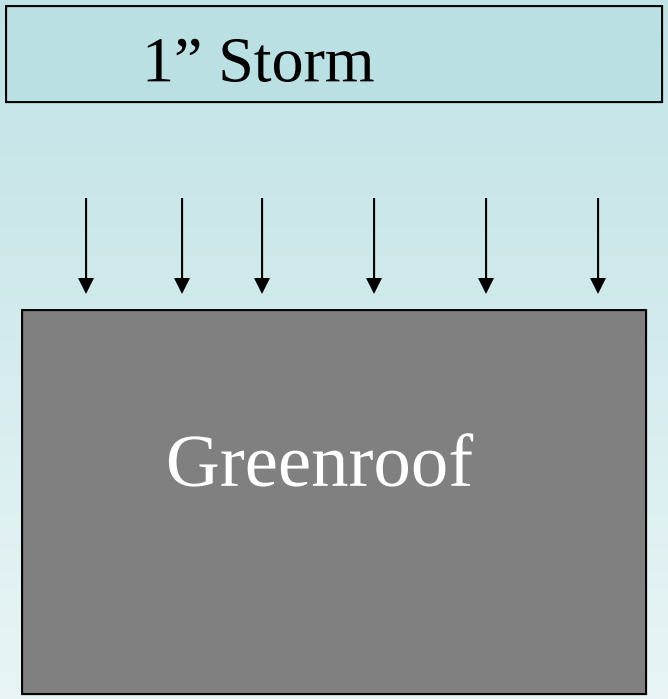


RO=693-115P+
0.001P2 -0.8*S

Empirical vs Mechanistic Model Example

Empirical

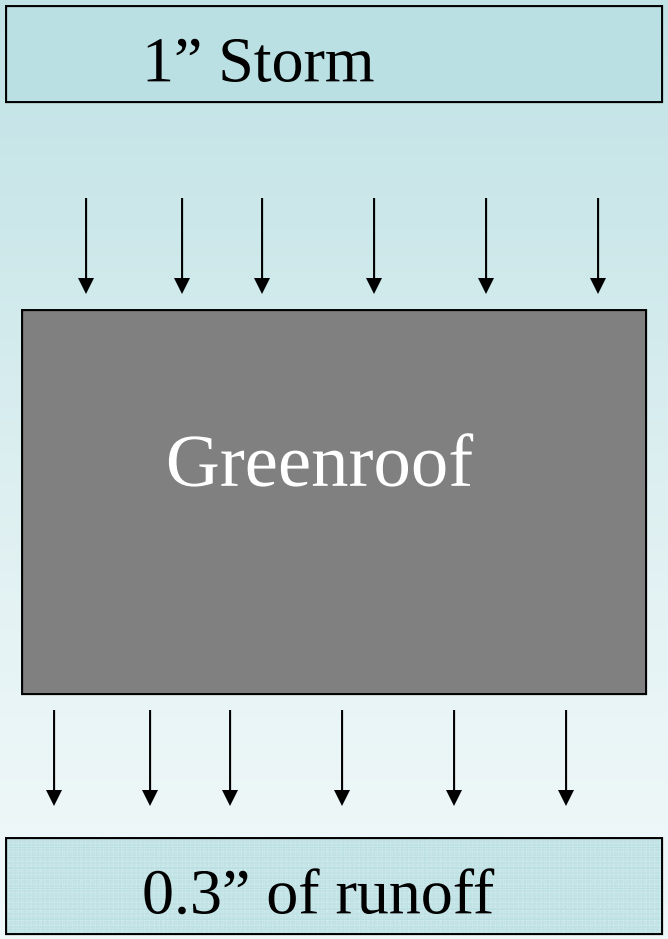
Mechanistic



Empirical vs Mechanistic Model Example

Empirical

- Relies more heavily on data derived from experiments
- Less knowledge of underlying processes that have generated the data



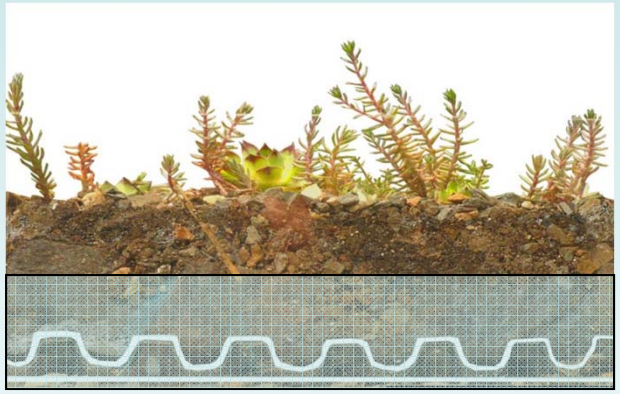
Mechanistic

Empirical vs Mechanistic Model Example

1” Storm

Empirical

- Relies more heavily on data derived from experiments
- Less knowledge of underlying processes that have generated the data

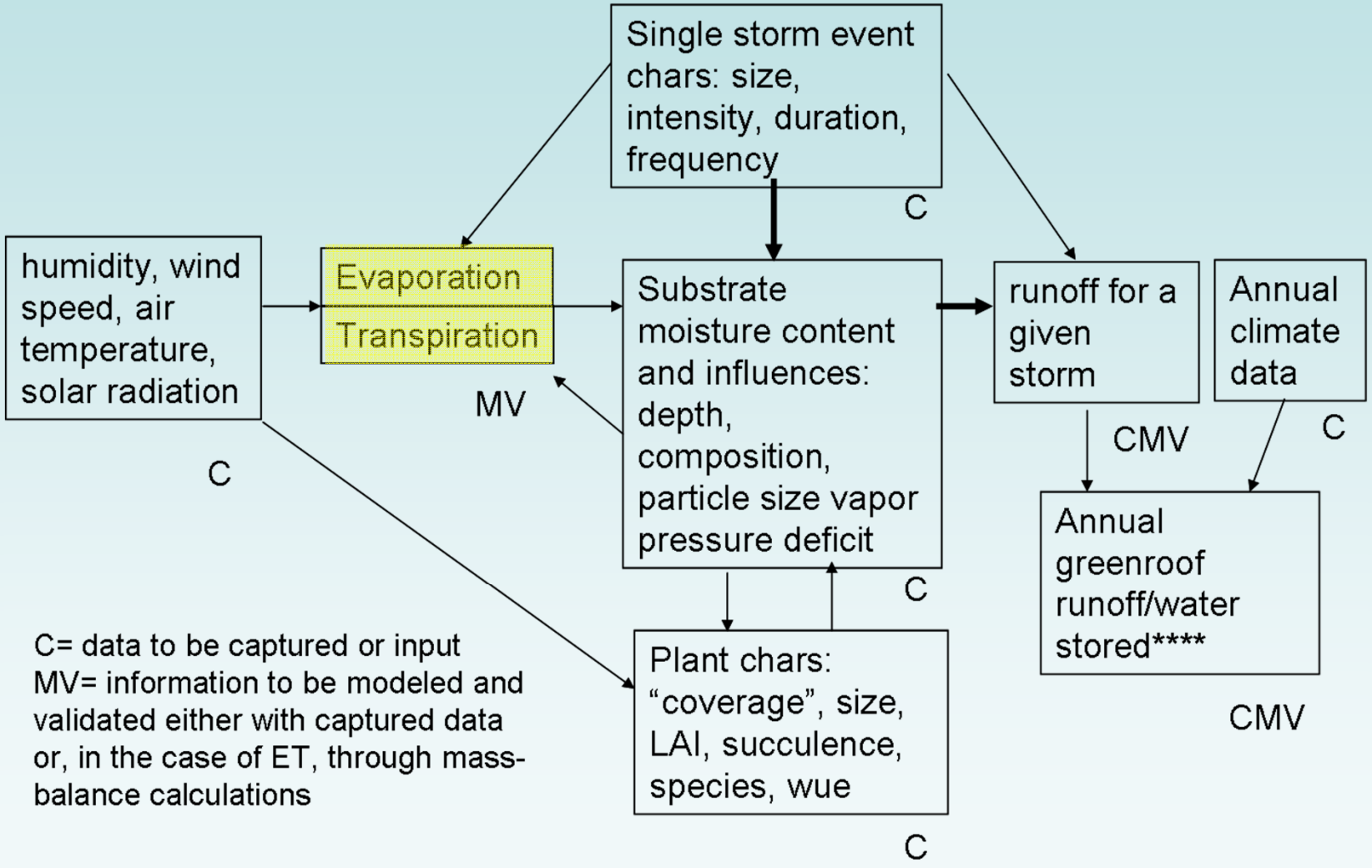


0.3” of runoff

Mechanistic

- A description of a system in terms of its constituent parts
- Often involve simulations
- Can be based on empirical data

The greenroof water cycle: P= ET+R+I



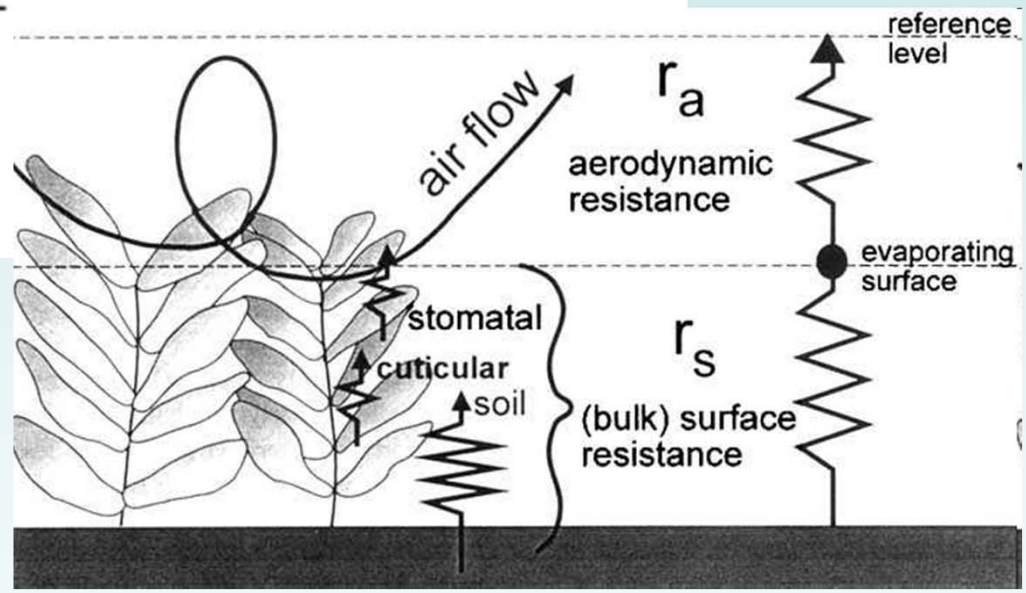
C= data to be captured or input
MV= information to be modeled and validated either with captured data or, in the case of ET, through mass-balance calculations

FAO 56 Penman-Monteith equation

Penman-Monteith equation

The Penman-Monteith form of the combination equation is:

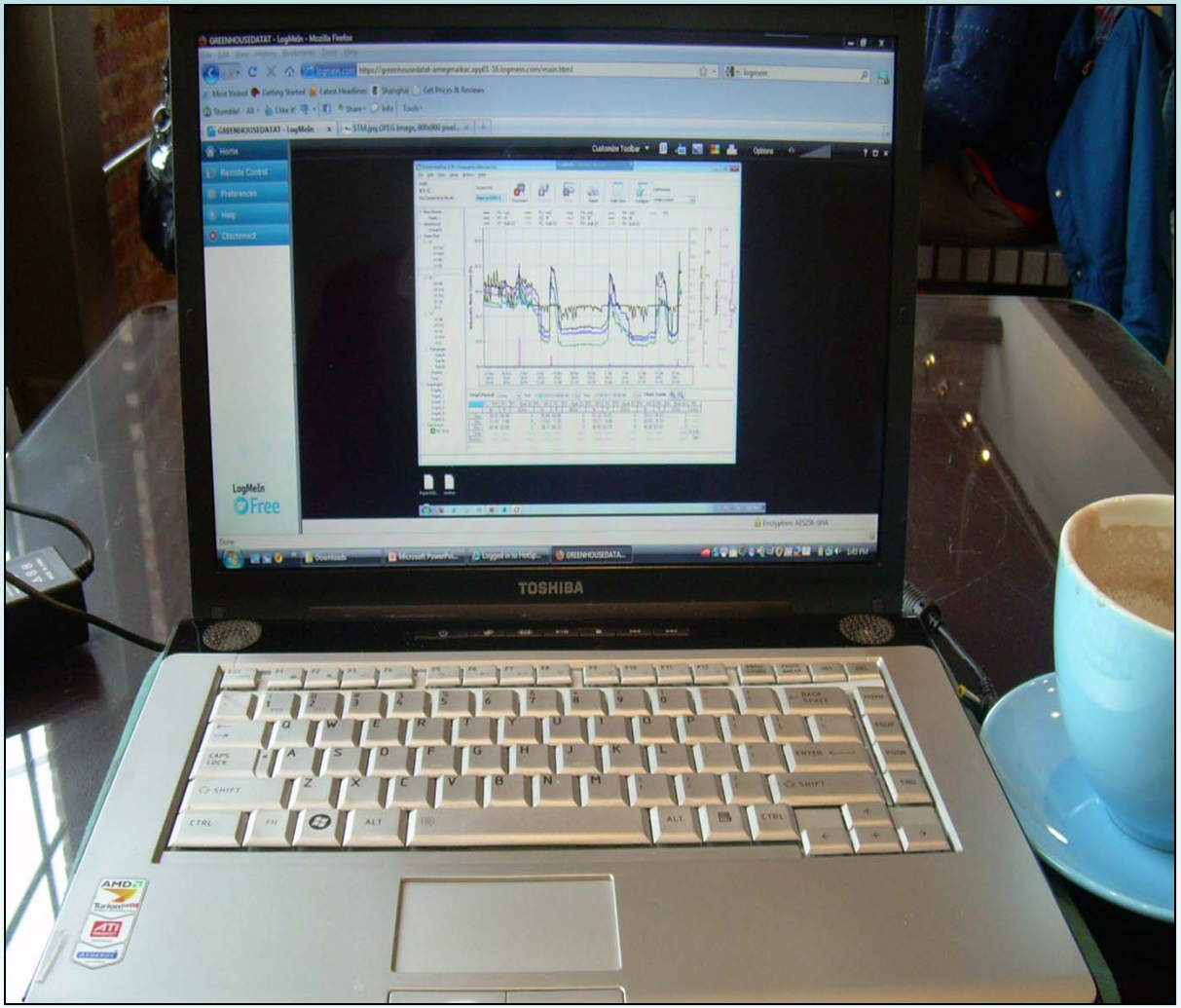
$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$



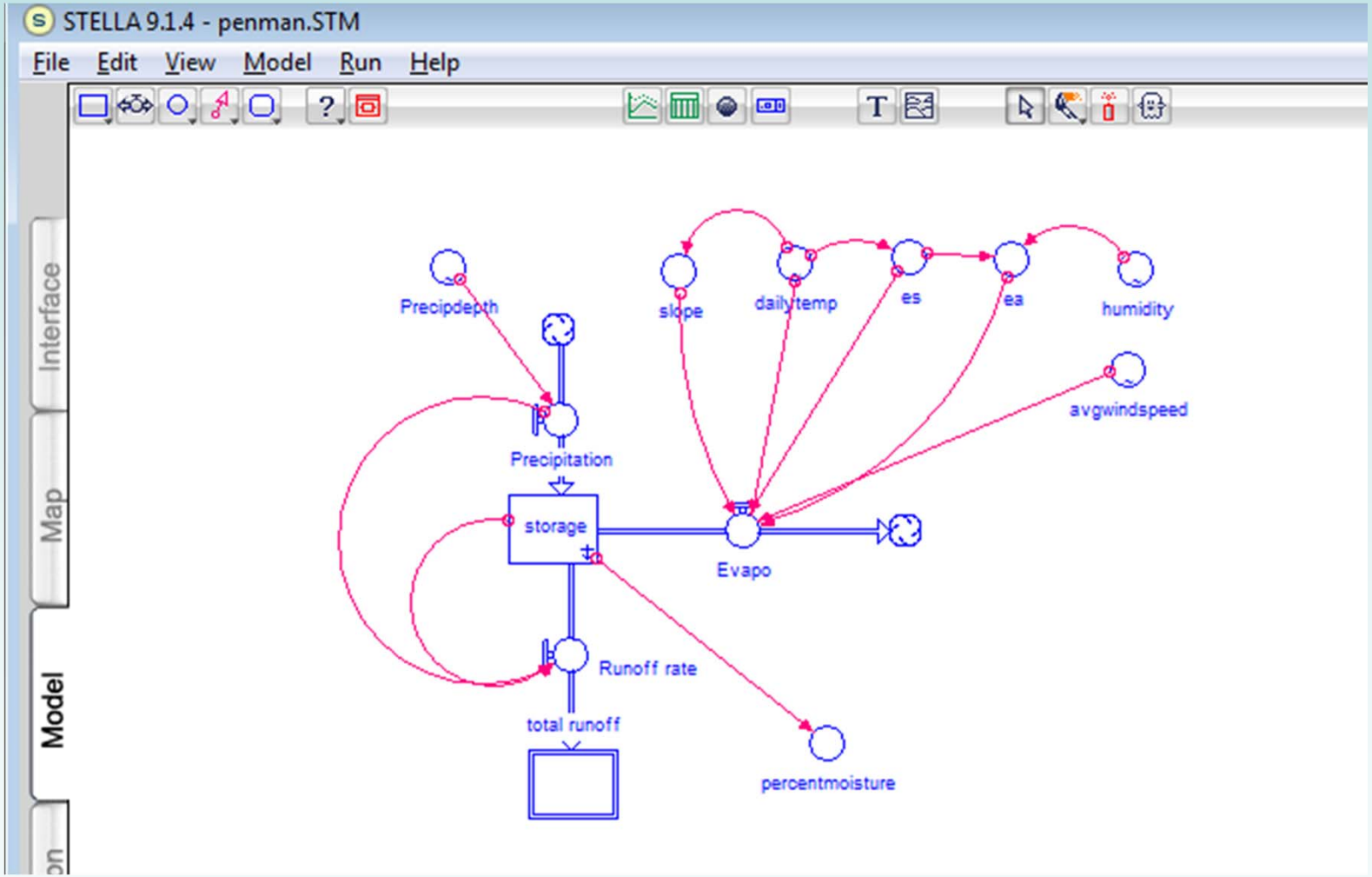
Allen et al. 1998

IV. Testing model predictions

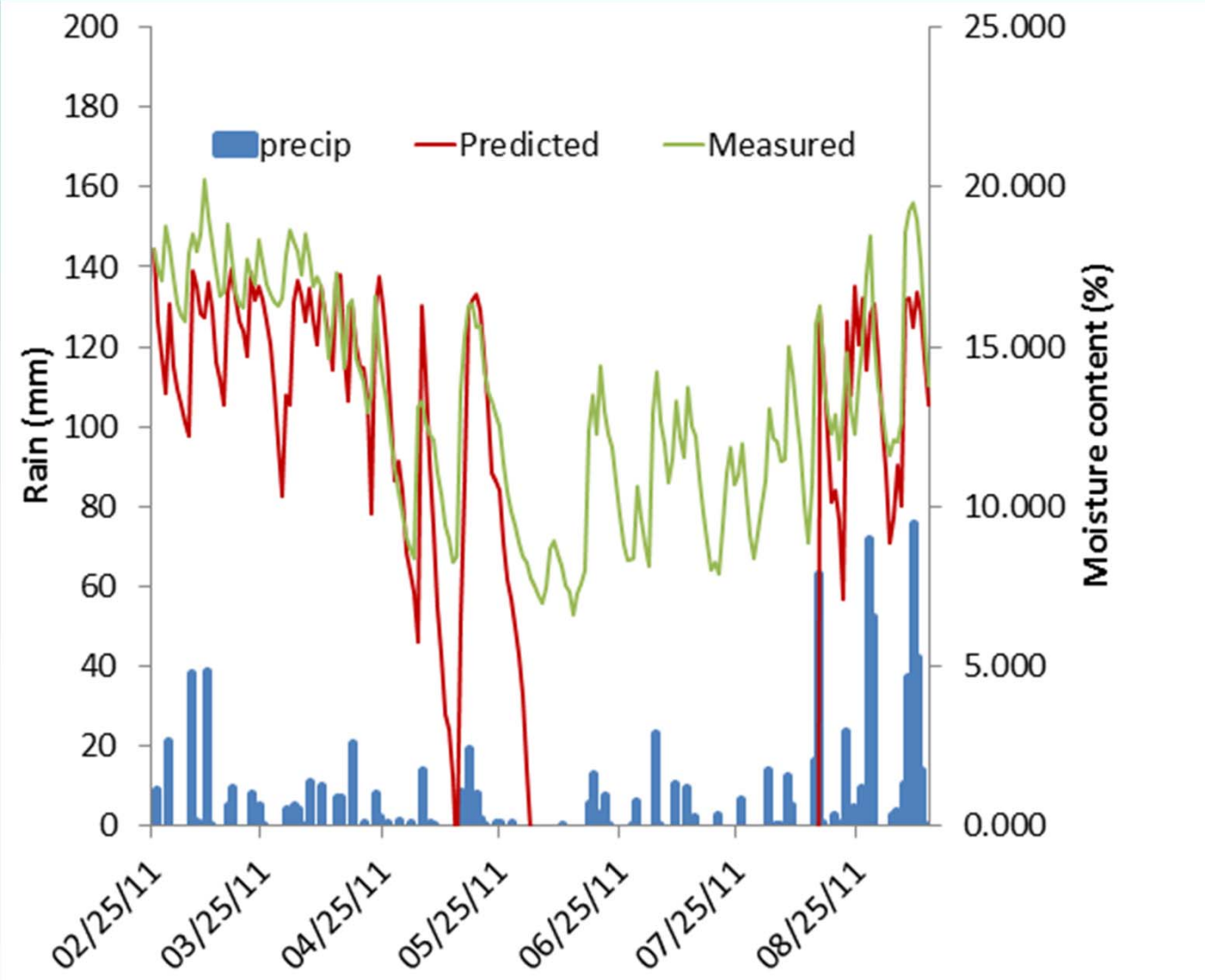
Decagon/Datatrac realtime access



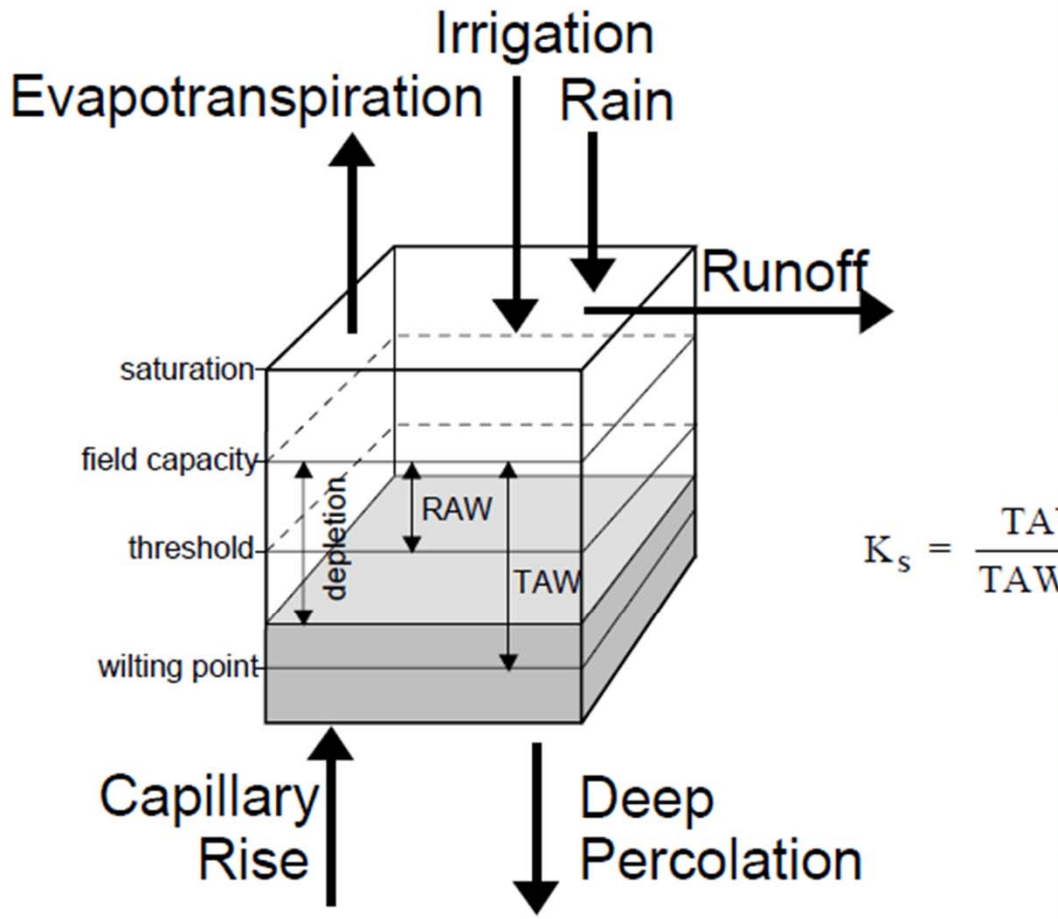
Building the model:



Verifying the model:



Adjustment to the FAO 56 Penman-Monteith equation:



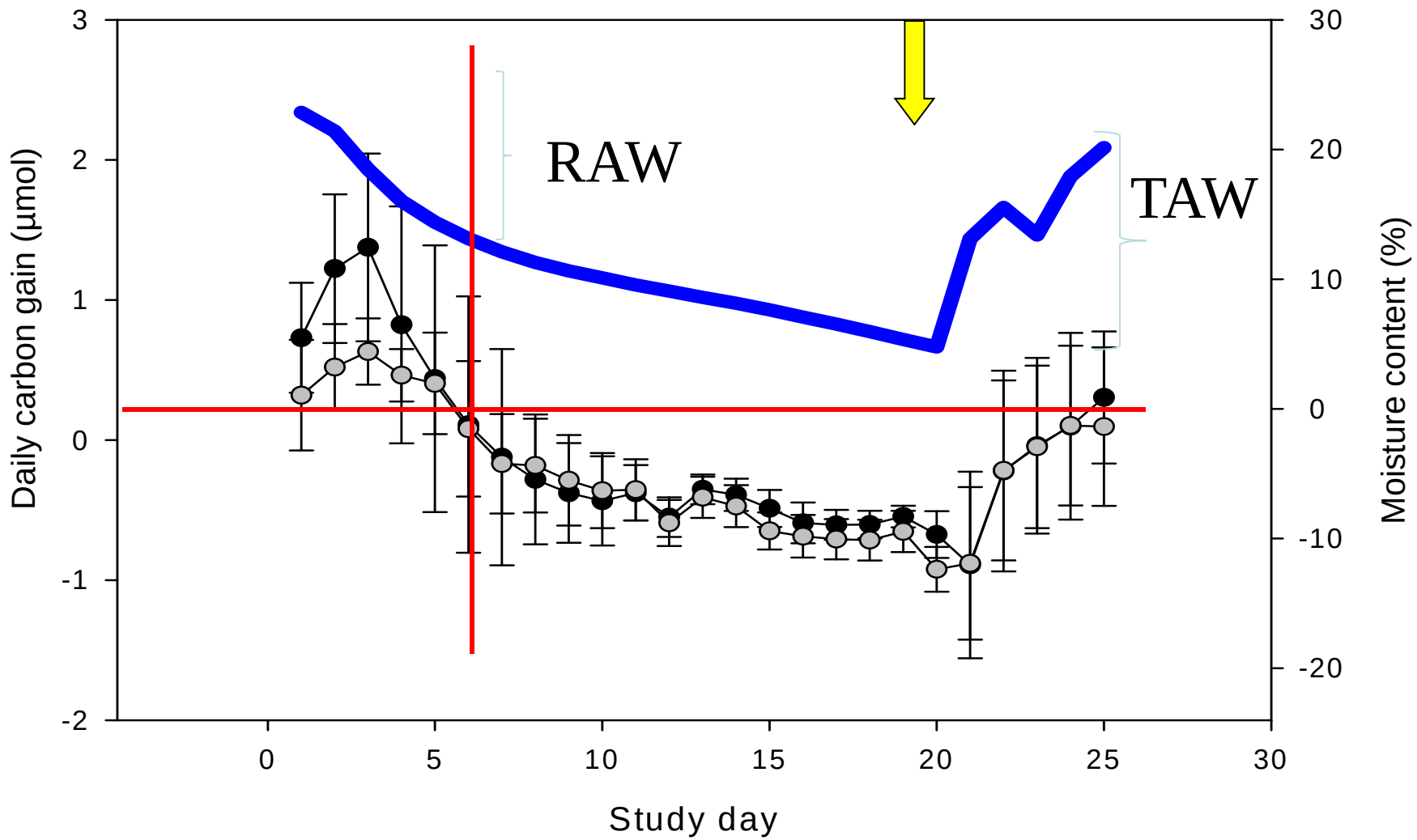
$$K_s = \frac{TAW - D_r}{TAW - RAW} = \frac{TAW - D_r}{(1-p)\ TAW}$$

Experimental plant chamber studies:

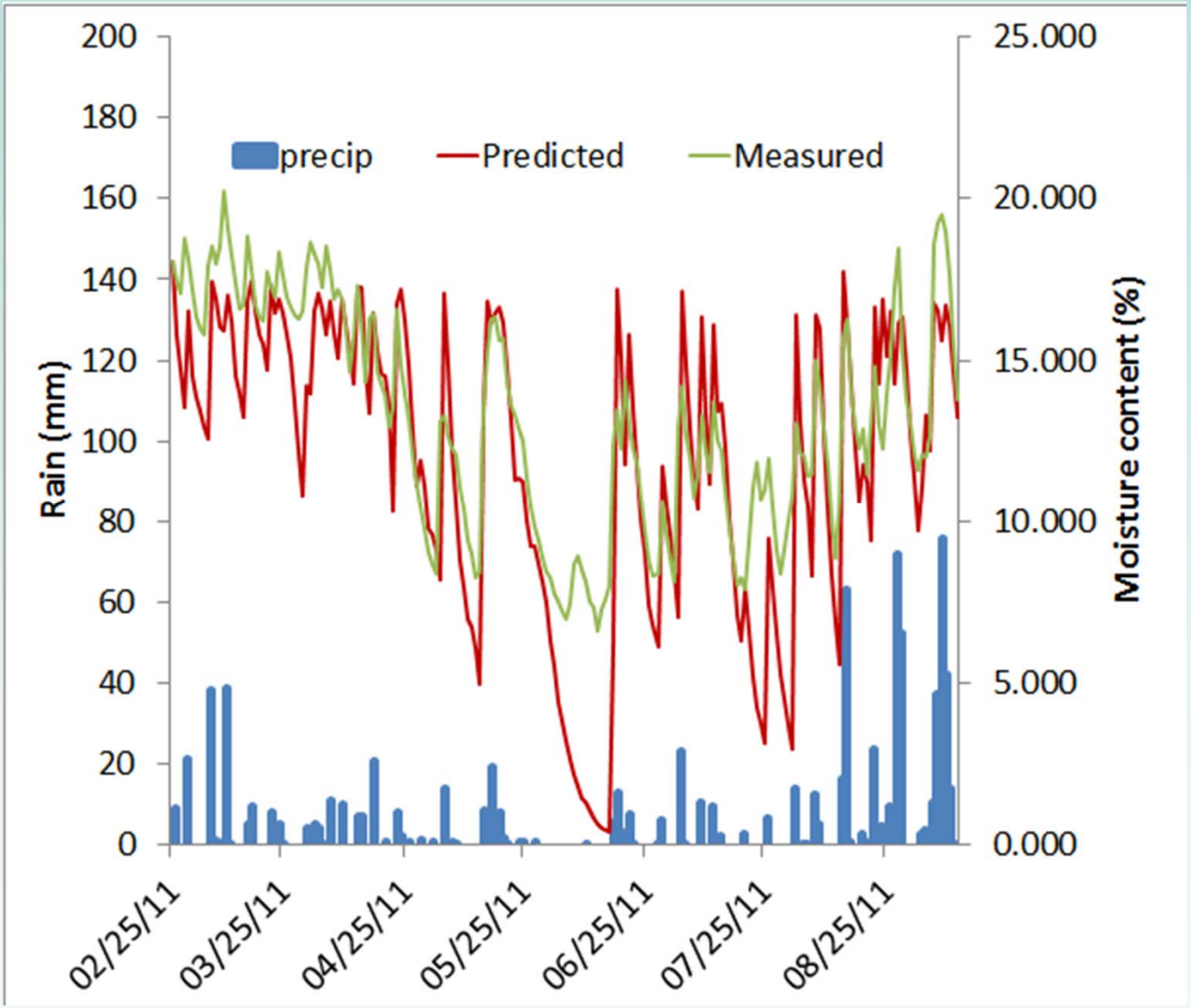
- 4 replicates of 2 species
- Constant temp (30C), controlled light; 12 hour day/night,
- Subjected to drought stress
- Major response variables are water loss and CO_2 exchange

THE UNIVERSITY OF GEORGIA
1785
▸ ABOUT UGA ▸ ADMISSIONS ▸ ACADEMICS ▸ RESEARCH ▸ OUTREACH ▸ STUDENT LIFE ▸ INSIDE UGA

Identifying readily and total available water:



Refining model predictions:

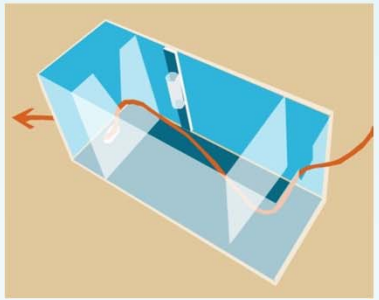


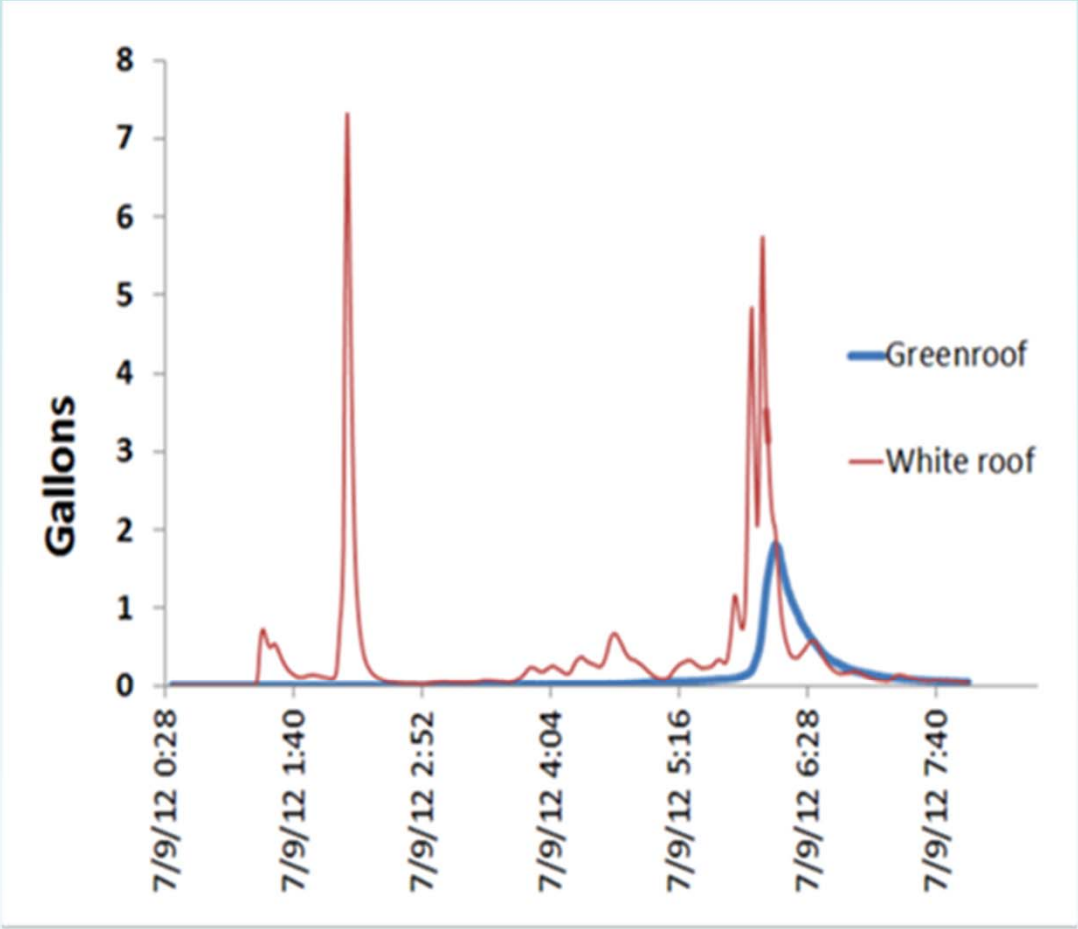
V. Future analyses

- Continue to model greenroof performance for different plant species
- Verify model with runoff data
- Sensitivity analysis
- Further model verification with data from **a real greenroof**

UMBC Roof

Runoff from a 0.67” July storm





http://www.umbc.edu/reslife/greenroof/

Thanks to suppliers and funders:

- **SCRI Grant (USDA)**
- **Phipps Conservatory**
- **NSF IGERT**
- **Sigma Xi**

For more information please visit:

http://urbansod.blogspot.com

Questions ?