Micro-scale to Meso-scale: An update on the IP3 sub-grid soil-water budget

by

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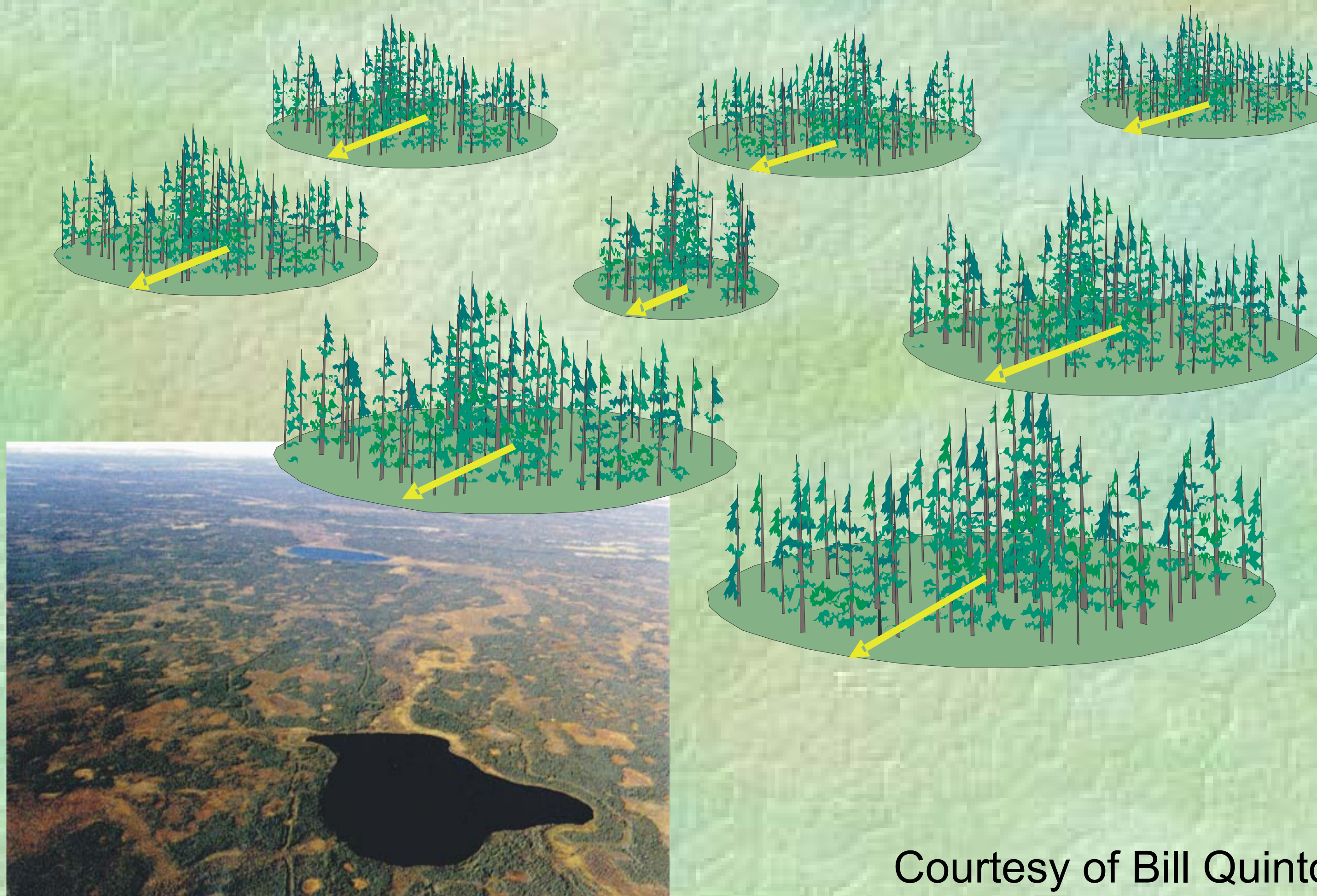
Outline

- Introduction
- Limitations of MESH (MAGS) soil-water budget
- Revised parameterization
- Verification
- Opportunities

Introduction: Modelling Imperatives

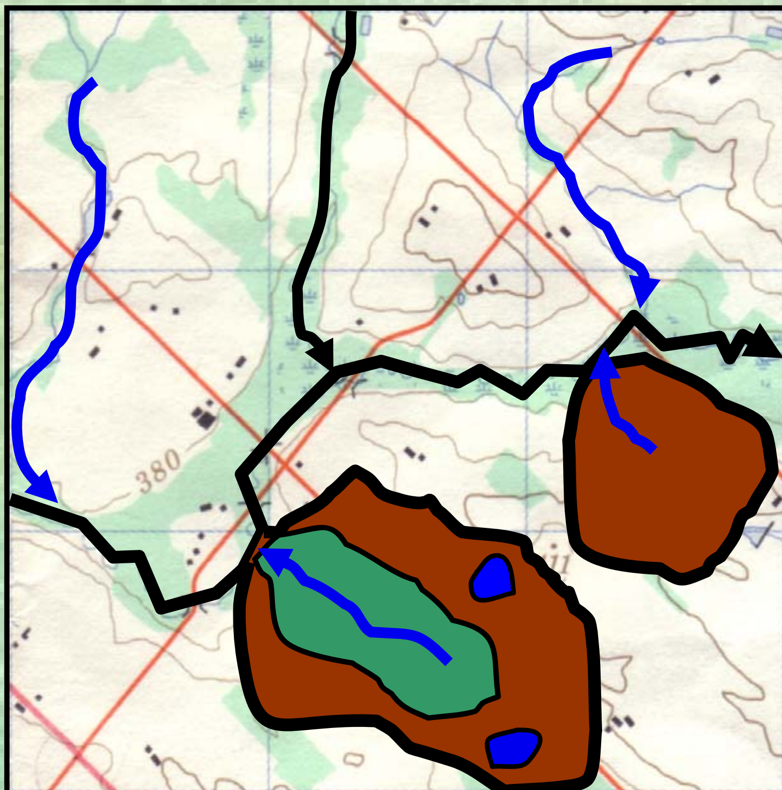
- 1) Use generic algorithms
  - -CRHM typically allows for explicit treatment of HRUs
  - -MESH/GEM groups representative HRUs
- 2) Do everything we can to minimize number of HRUs
- 3) Use distribution based algorithms
  - - sum fluxes by area
  - - or use pdfs of important properties
- **4) Embed as much physics as possible in the tile algorithms**

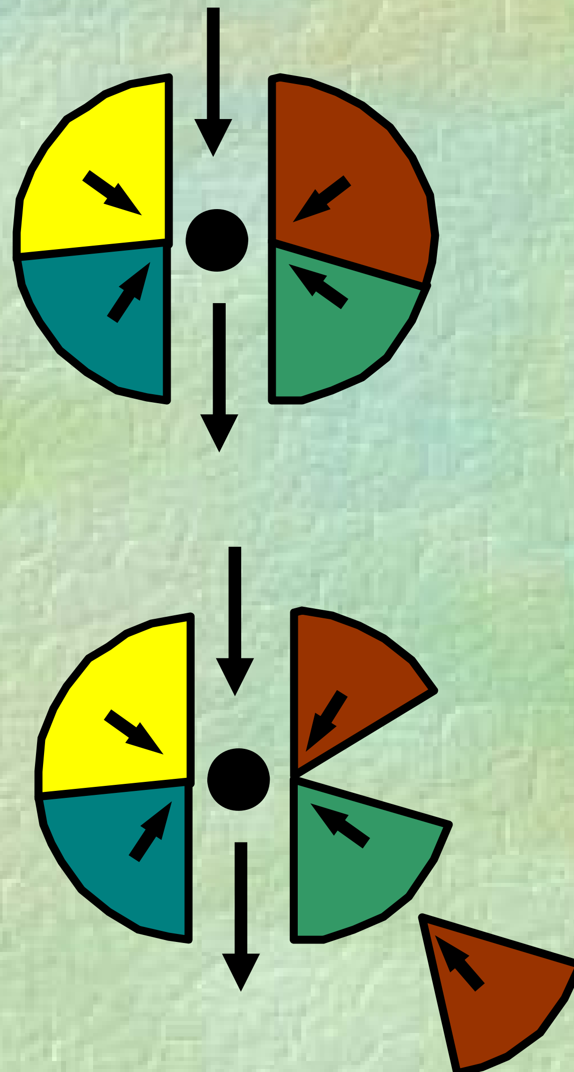
Peat Plateaus



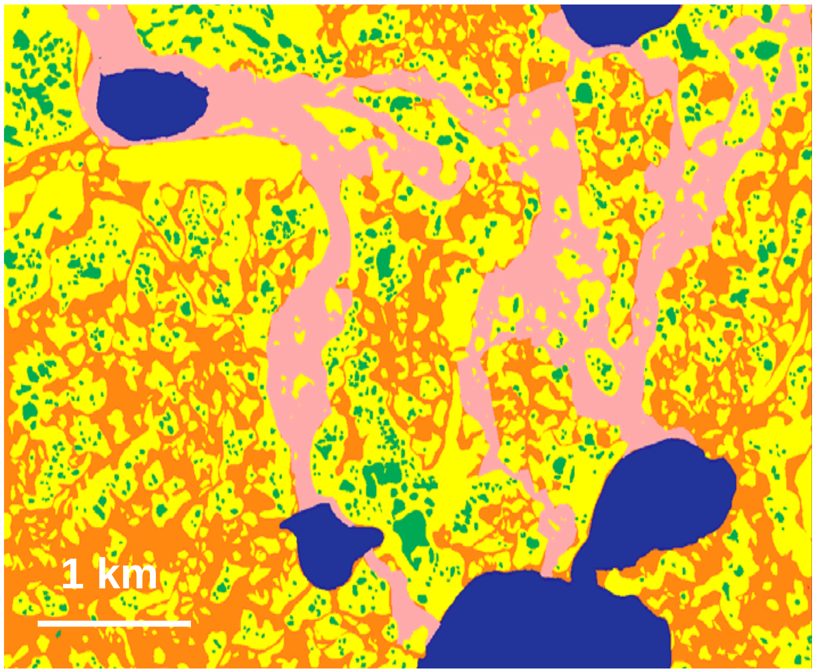
Courtesy of Bill Quinton

Rural Ontario





3) Use PDFs for Hydrologic Properties



Lake

Isolated bog

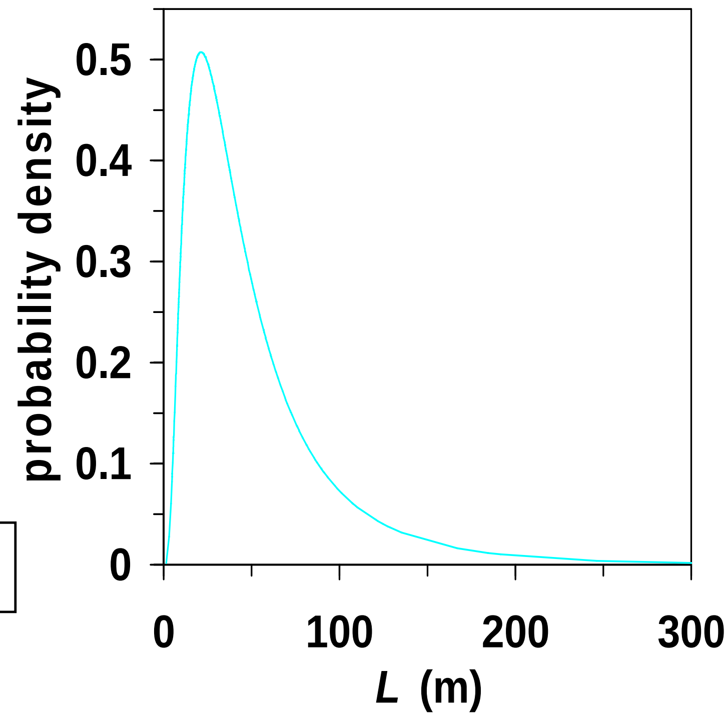
Connected bog

Peat plateau

Fen

Hydraulic radius

***L* = 2 * area / perimeter**



Courtesy of Bill Quinton

MAGS Tile

Surface Runoff:
Manning's Equation

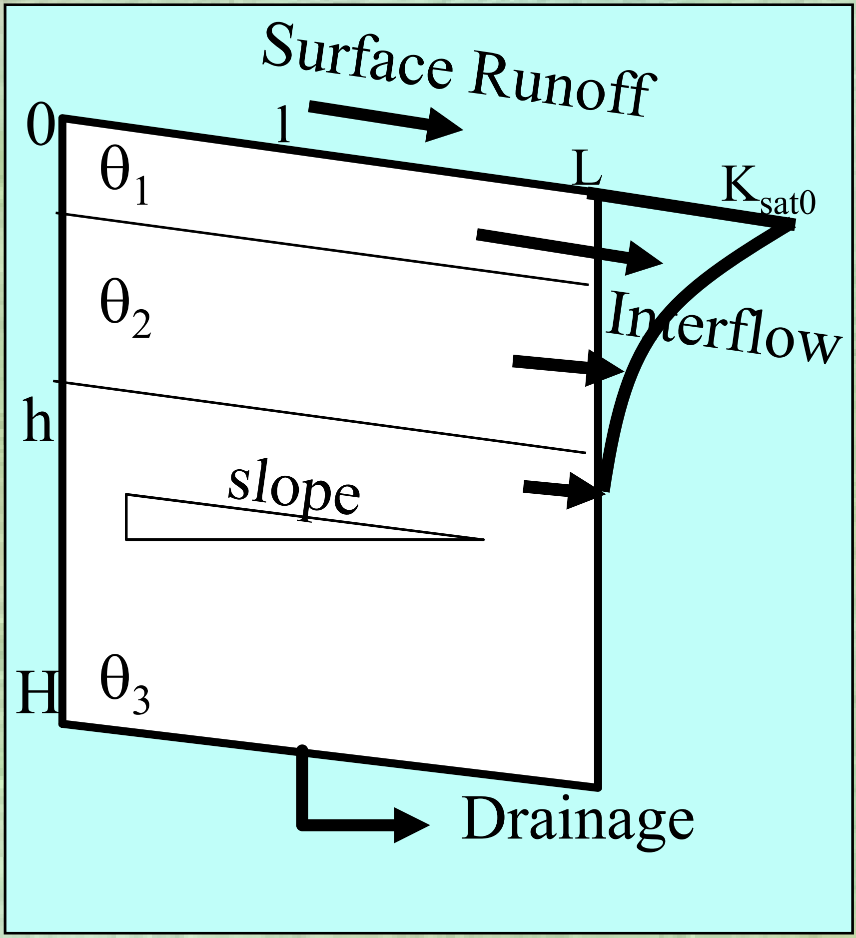
$$Q_{over} = \left(\frac{1}{n}\right) \cdot d_e^{5/3} \cdot \Lambda_I^{1/2} \cdot L_v$$

Infiltration redistribution interflow:
Richard's Equation

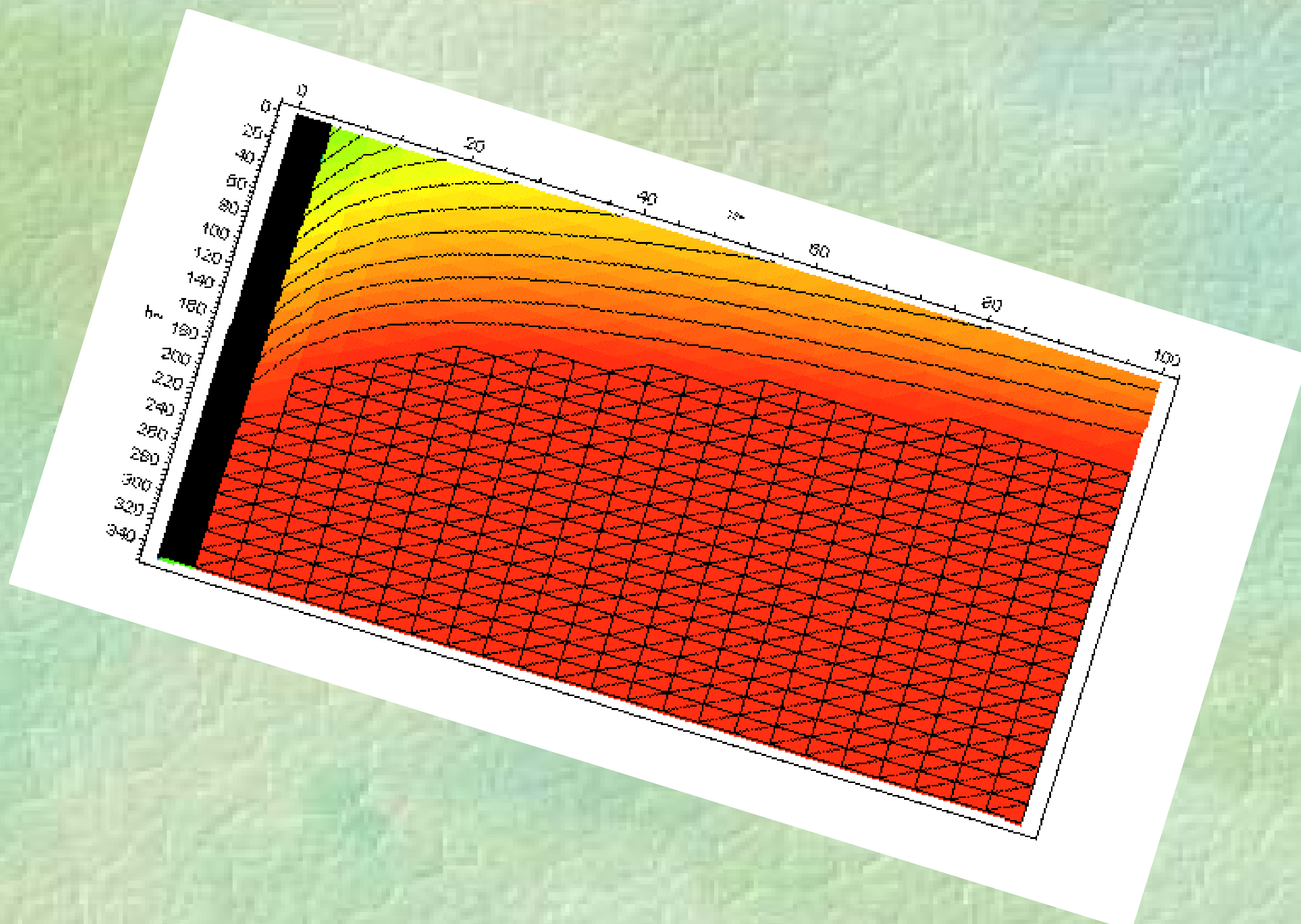
$$-\frac{\partial K_v(\theta)}{\partial z} + \frac{\partial}{\partial z}\left[K_v(\theta)\frac{\partial \psi(\theta)}{\partial z}\right] = \frac{\partial \theta}{\partial t}$$

Drainage or Recharge:
Darcy's Law

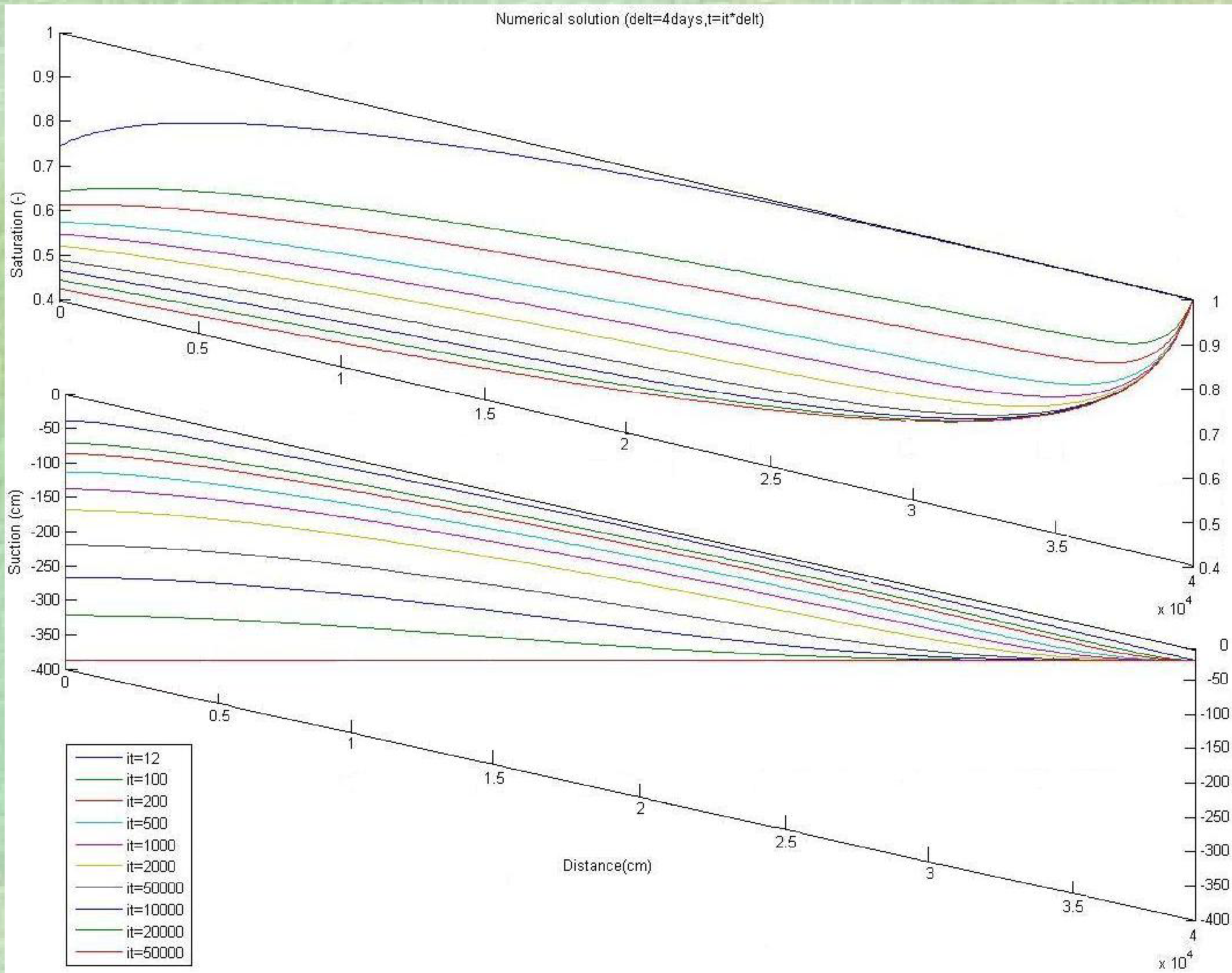
$$q_{drain} = K_v(\theta_3)$$



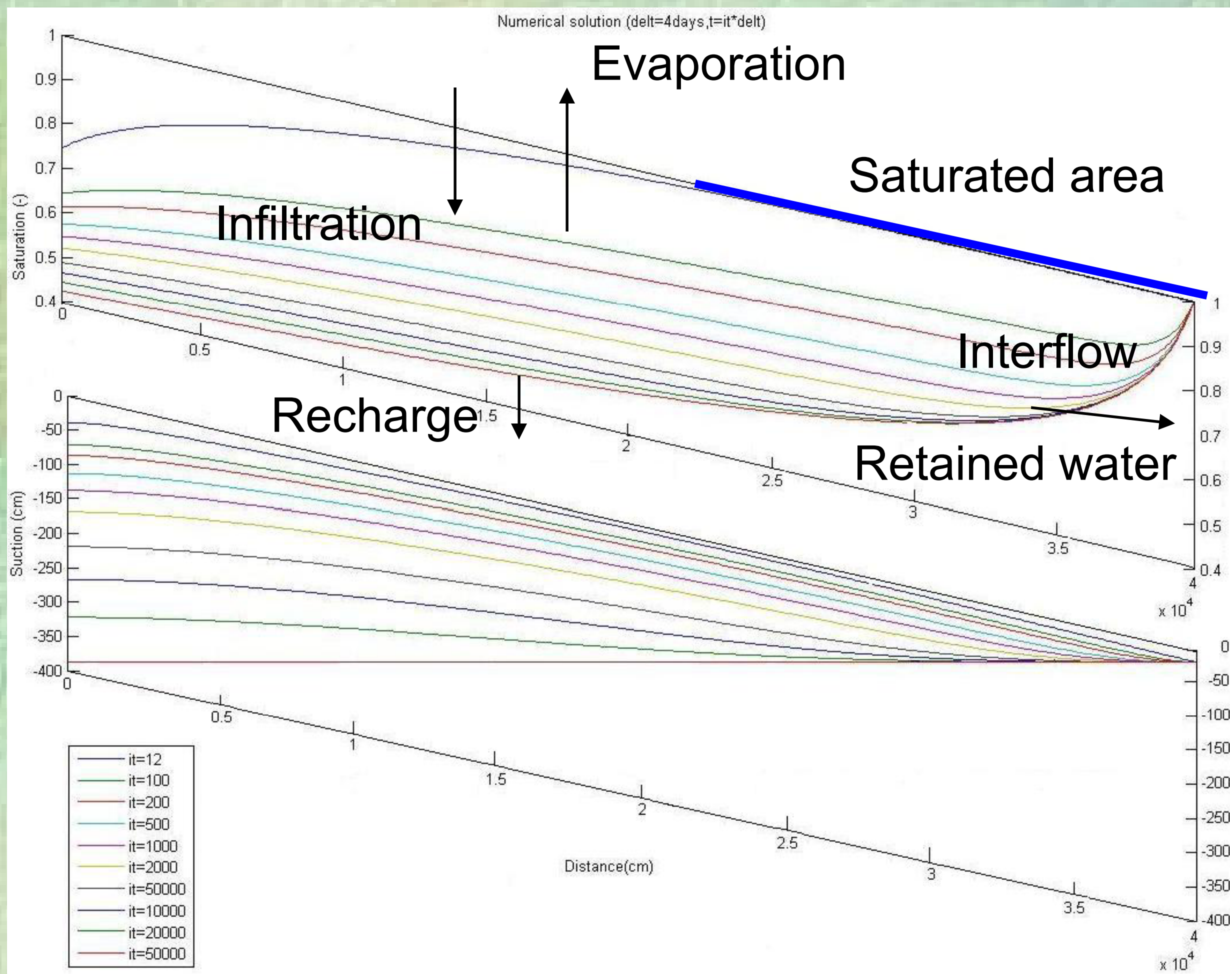
MAGS Tile



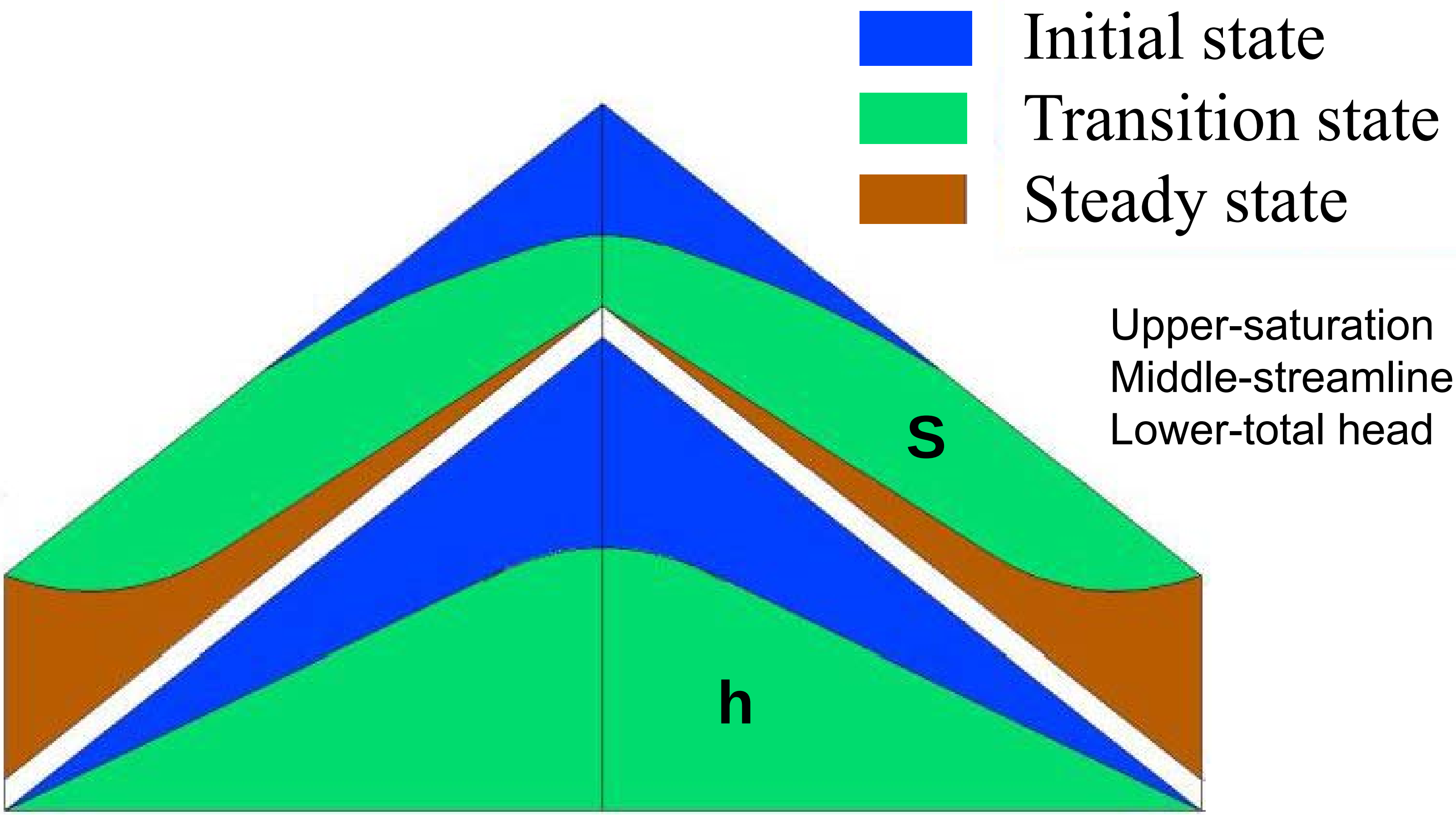
0
20
40
60
80
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340


Numerical solution (delt=4days,t=it*delt)
Saturation (-)
Suction (cm)
Distance(cm)
x 10^4
it=12
it=100
it=200
it=500
it=1000
it=2000
it=50000
it=10000
it=20000
it=50000

Easy to Interpret



IP3 Tile?



Upper-saturation
Middle-streamline
Lower-total head

New Parameterization

$$S = \left(\frac{x + \varepsilon}{x_s + \varepsilon}\right)^{\frac{\left(1 - x/x_s\right)^z}{c-1}} \qquad \psi = \psi_0 S^{-b}$$

$$\left.\frac{\partial \psi}{\partial x}\right|_{x=0,0,t} = \Lambda \Rightarrow \varepsilon(t) \qquad \int_0^{x_s} S\,dx = K_s \Lambda t \Rightarrow x_s(t)$$

Field Capacity Comparison

Flow ceases when suction gradient equals slope. Thus,

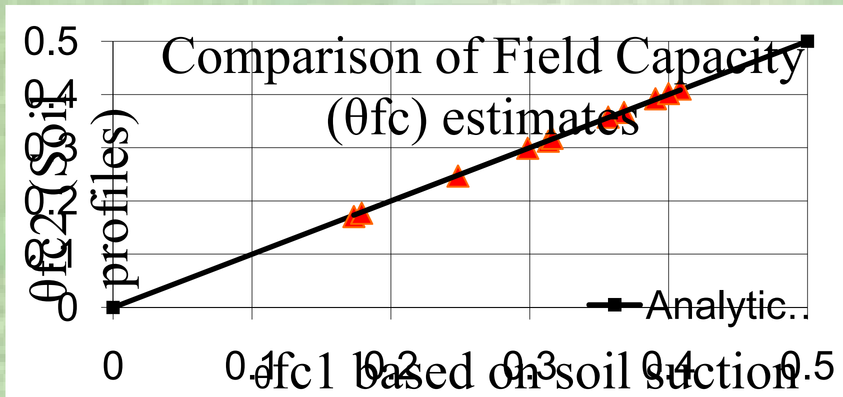
$$\psi = \psi_0 - \Lambda(L - x)$$

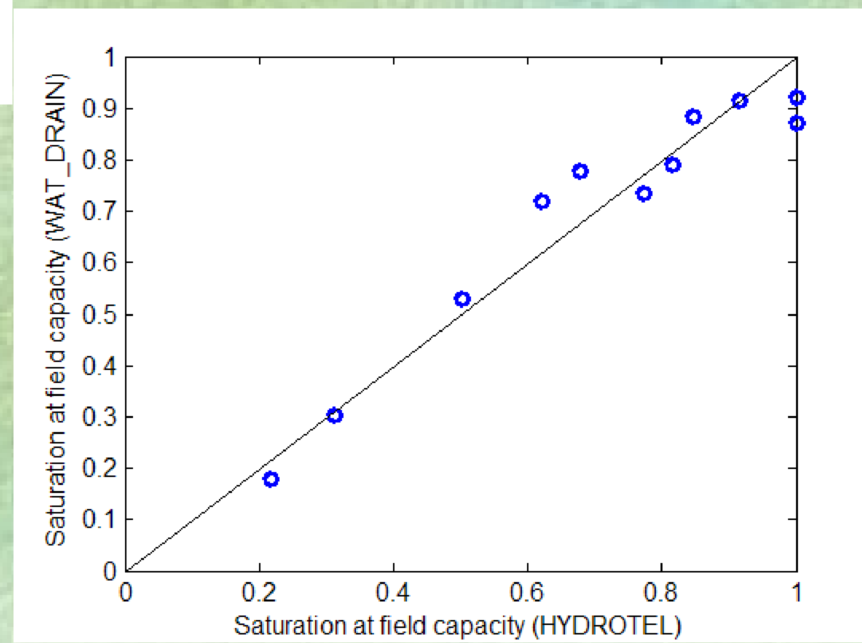
and

$$\bar{S}_{fc} = \frac{1}{(b-1)}\left(\frac{-\psi_a b}{L\Lambda}\right)^{1/b}\left[(3b+2)^{(b-1)/b} - (2b+2)^{(b-1)/b}\right]$$

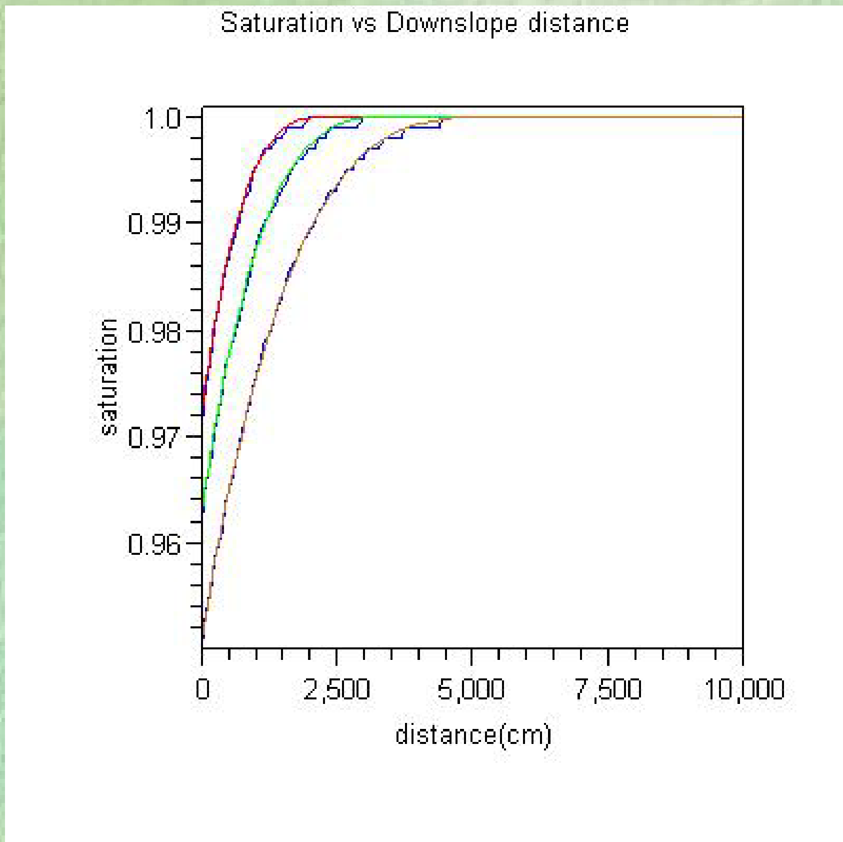
Note the second equation includes **both** topographic and soil parameters.

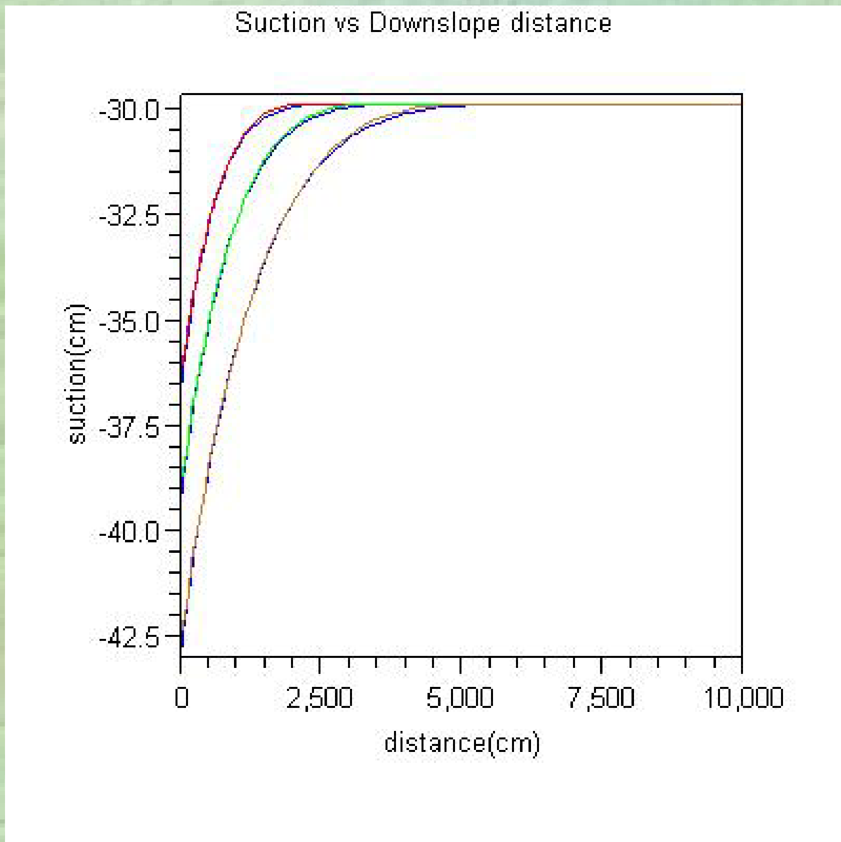
Field Capacity Comparison





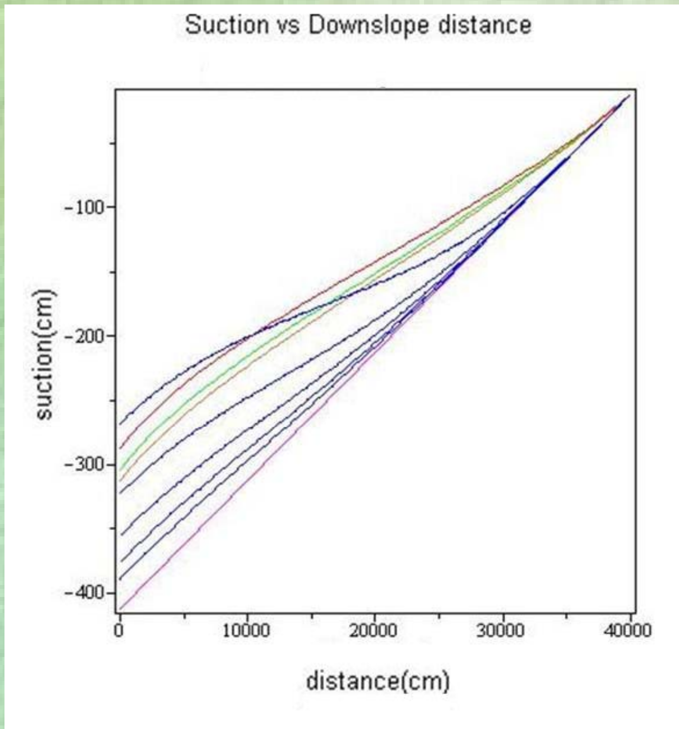
Numerical Analysis Comparison

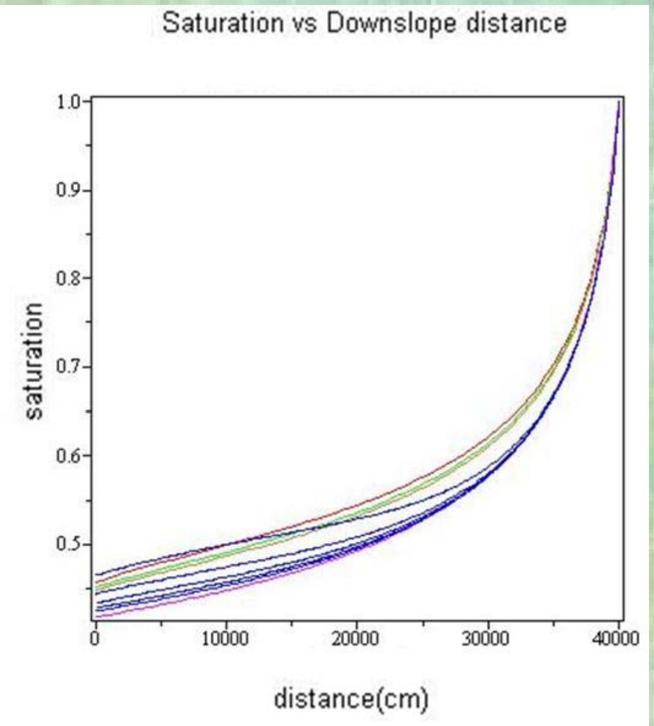




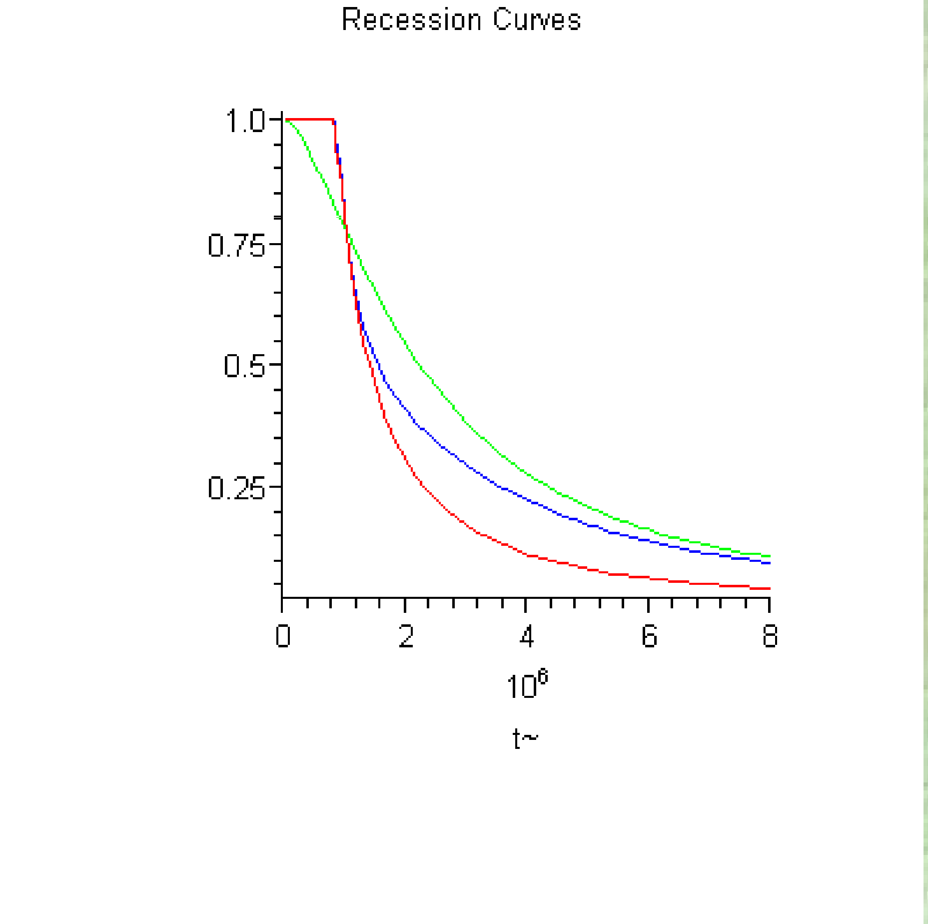
Silty Loam 1,2 and 3 months

Numerical Analysis Comparison

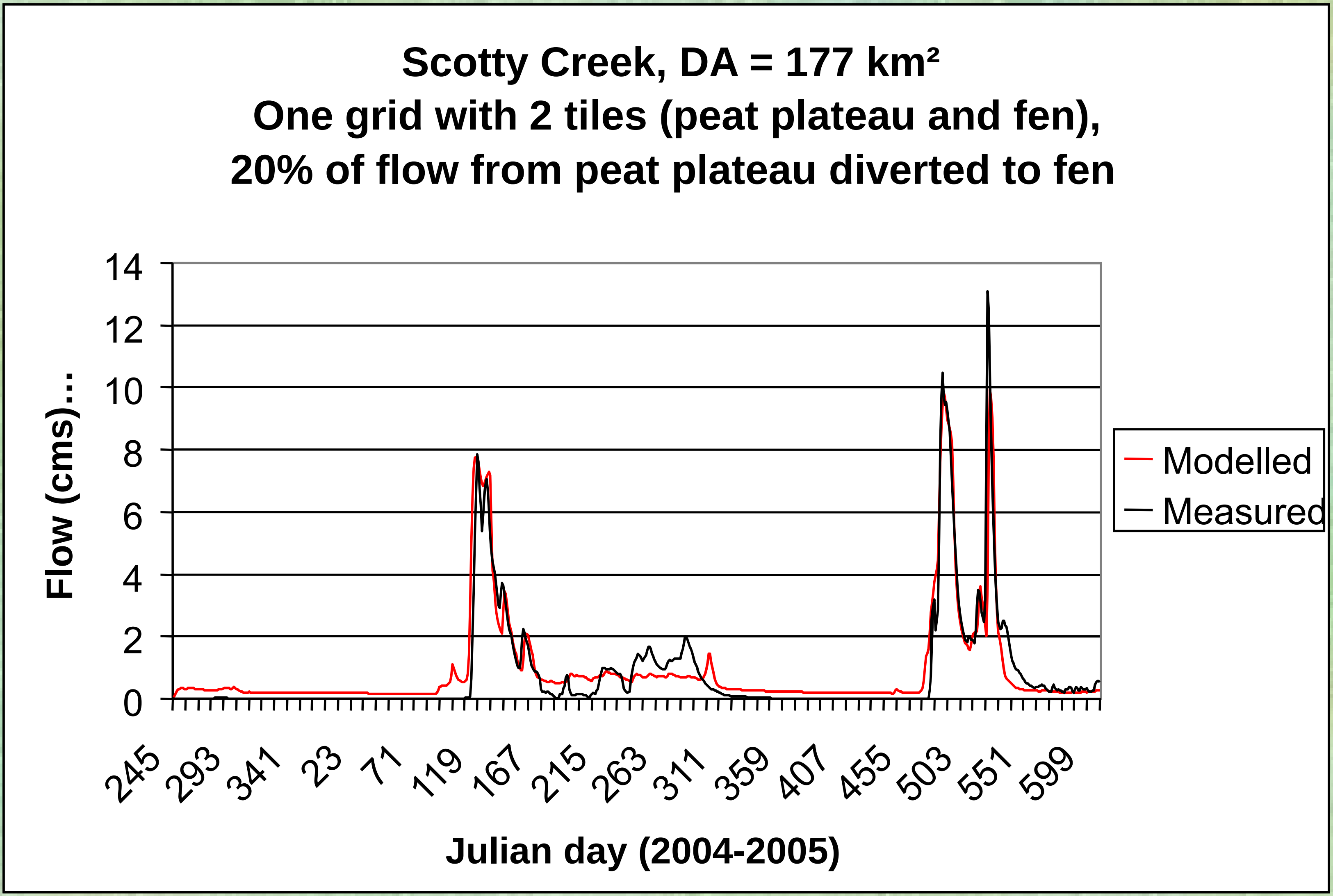




Improved Recession Curves

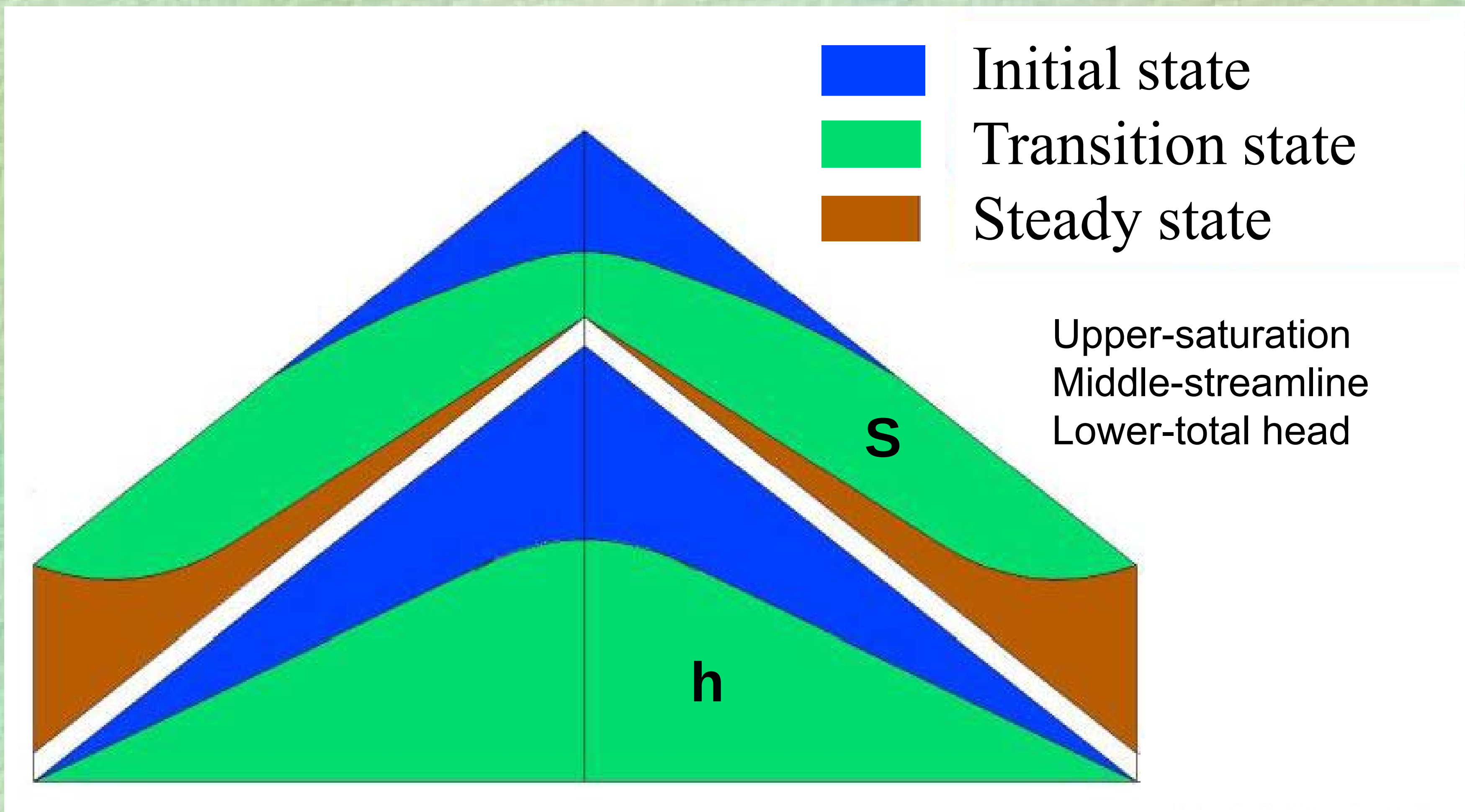


Red line is a typical gravity dominated curve. Green line is the corresponding suction dominated solution. WATDrainV2 uses an empirical blend of these. WATDrainV3 will use Equation (1) which is the blue line in Figure 3.



Scotty Creek, DA = 177 km²
One grid with 2 tiles (peat plateau and fen),
20% of flow from peat plateau diverted to fen
Flow (cms)...
14
12
10
8
6
4
2
0
245
293
341
23
71
119
167
215
263
311
359
407
455
503
551
599
Julian day (2004-2005)
Modelled
Measured

IP3 Tile


Initial state
Transition state
Steady state
Upper-saturation
Middle-streamline
Lower-total head
s
h