Soil-vegetation-atmosphere transfer in regional scale climate modeling

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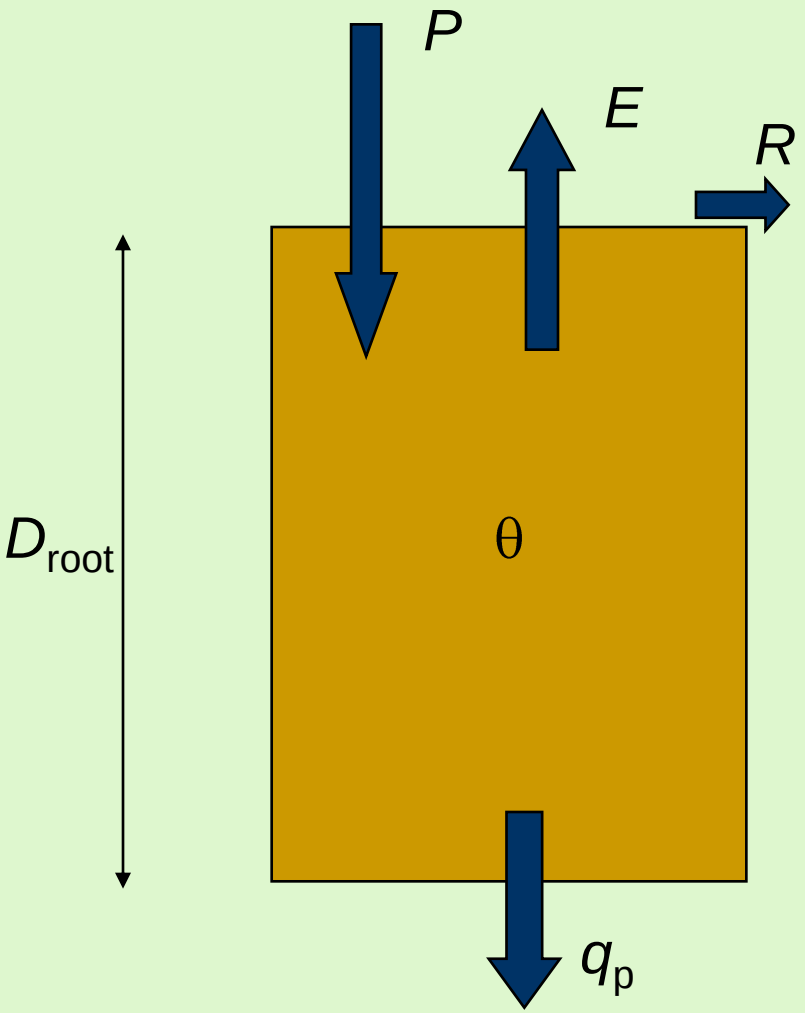
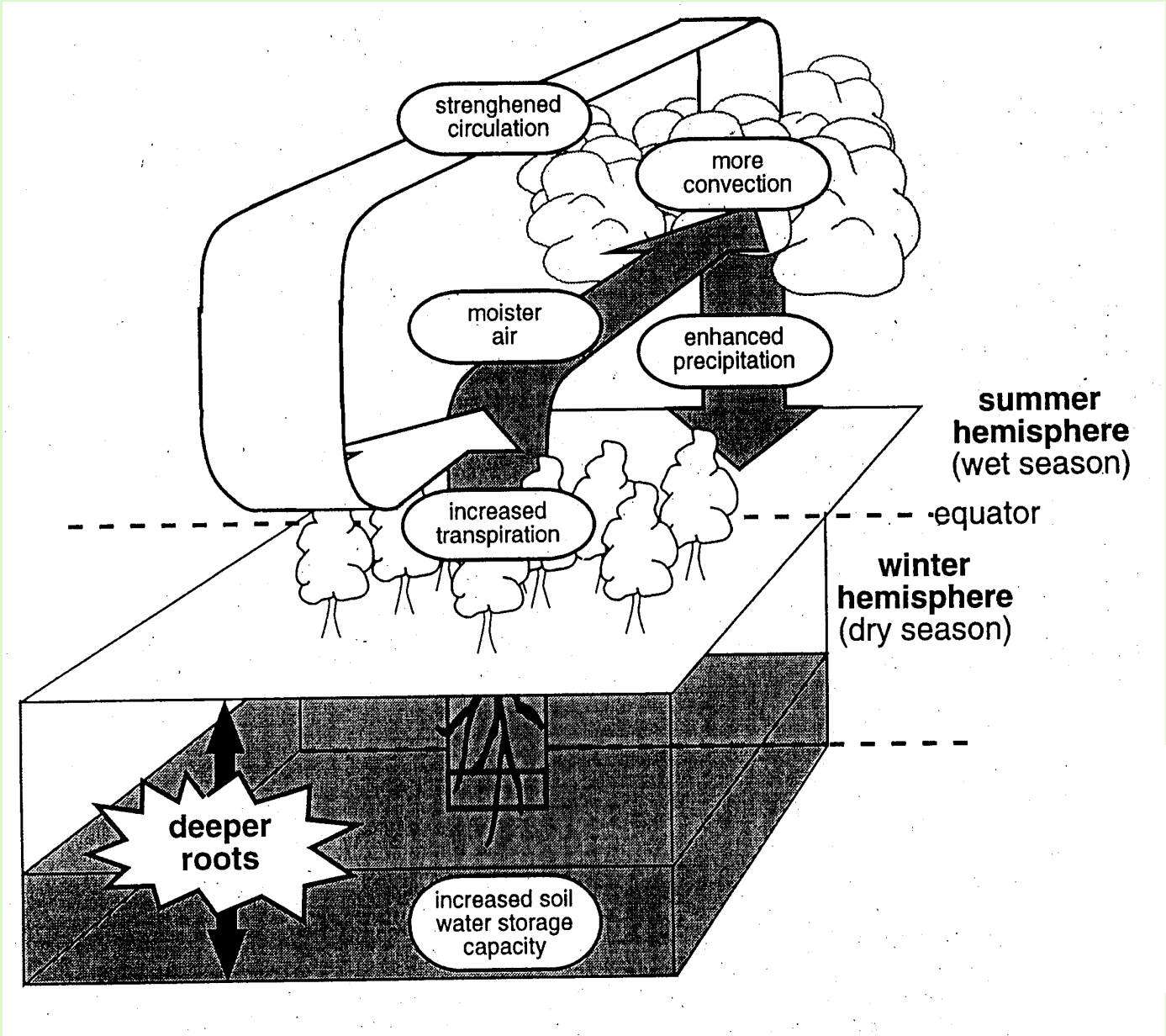
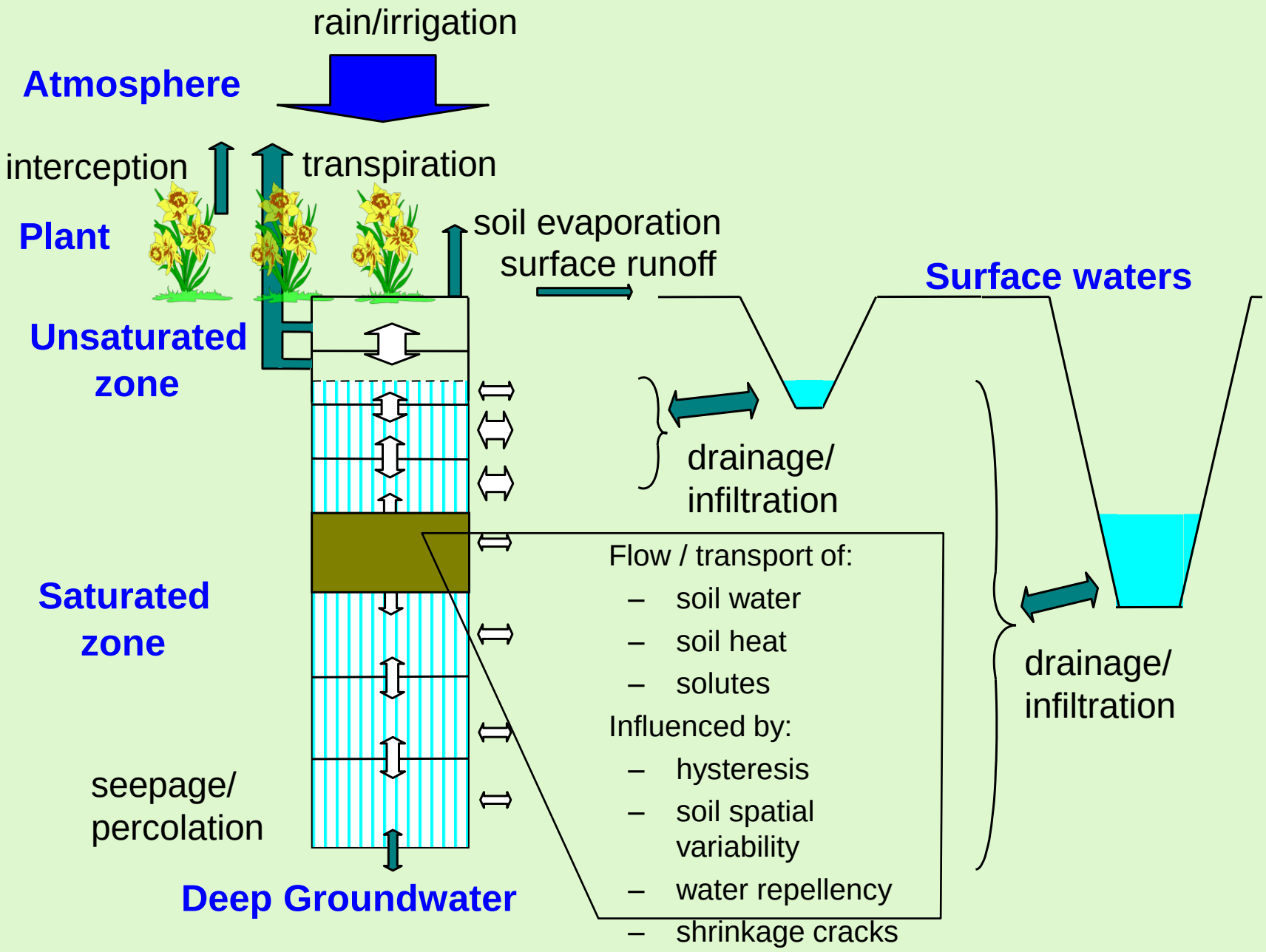
Water balance components



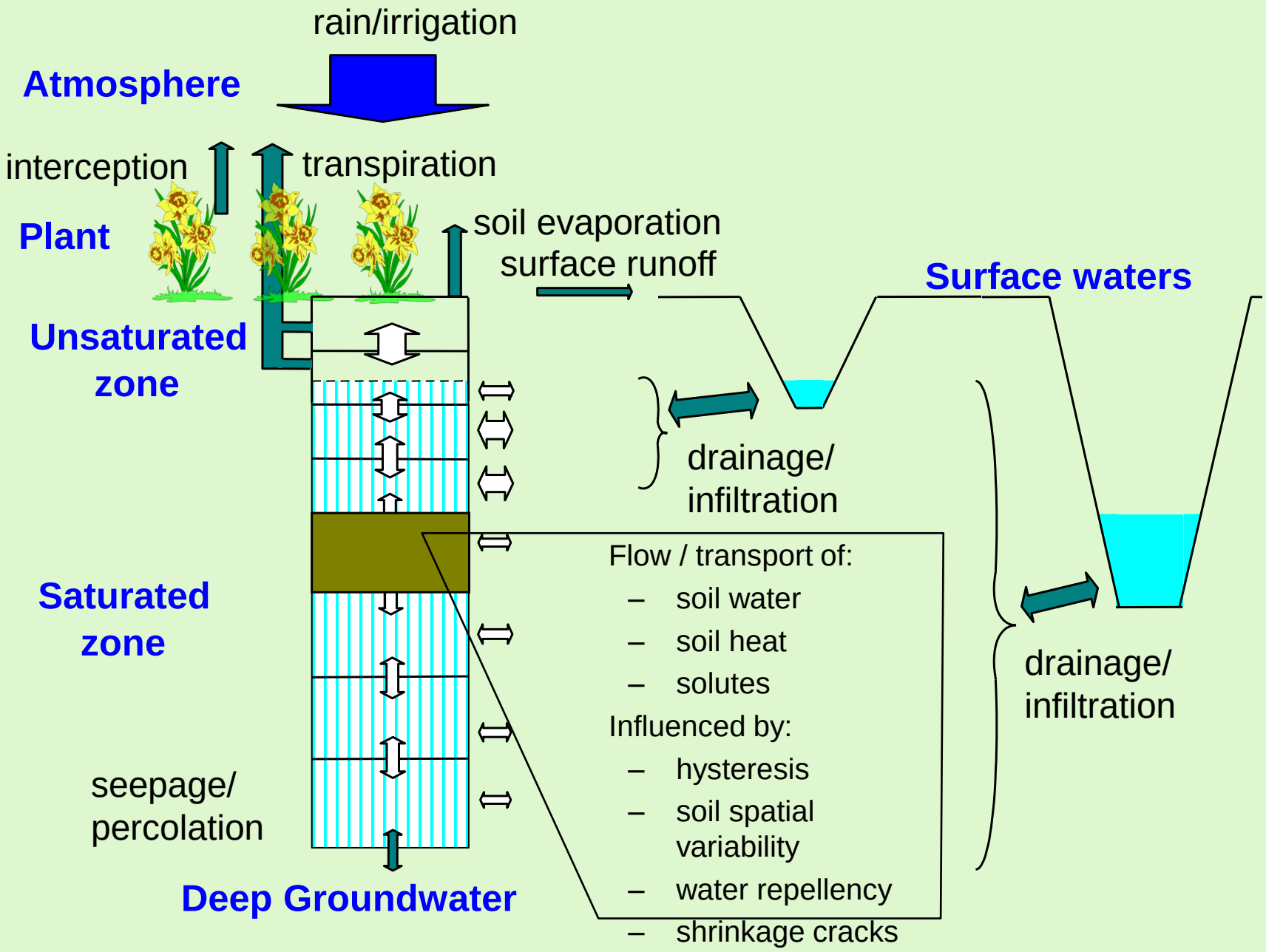
Global circulation



Processes schematization

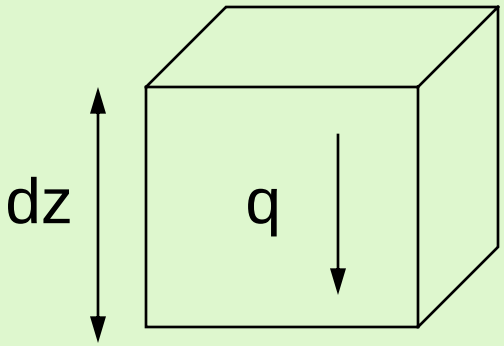


Processes schematization



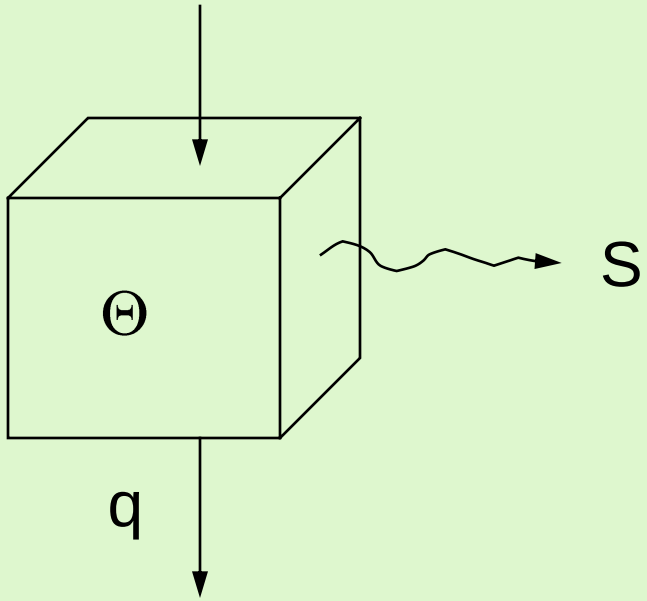
Soil water flow equation

Darcy



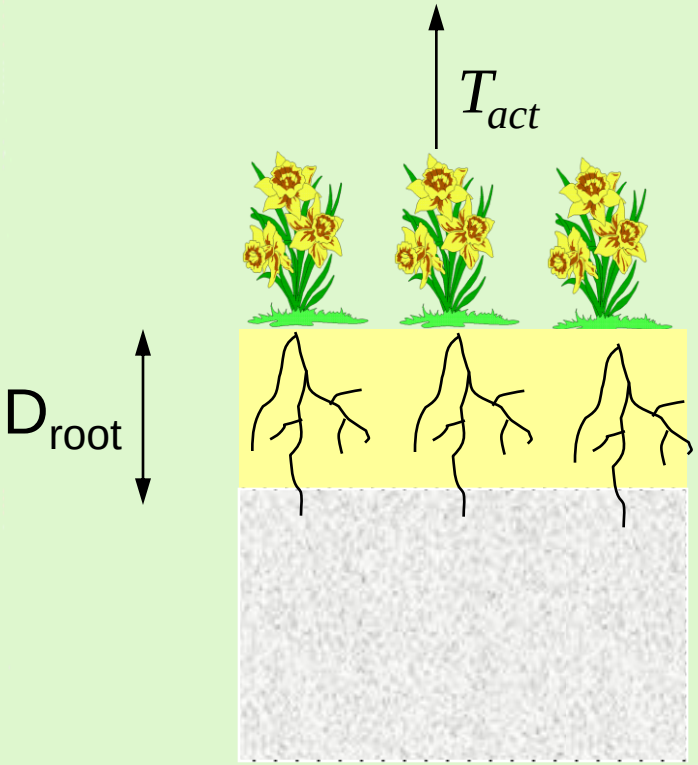
$$q = -K\frac{\partial H}{\partial z}$$

Continuity

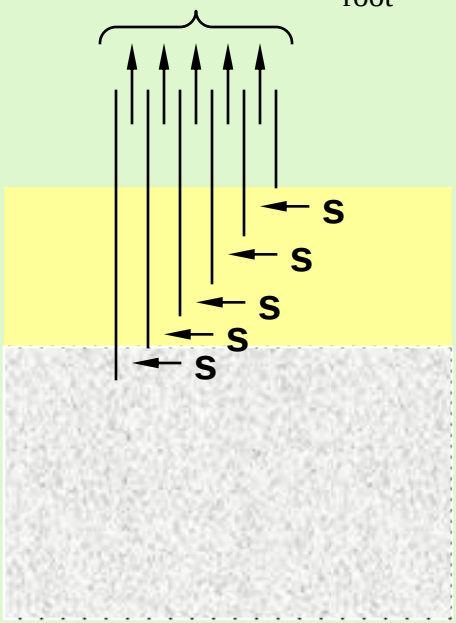


$$\frac{\partial \theta}{\partial t} = -\frac{\partial q}{\partial z} - S$$

Water uptake by roots

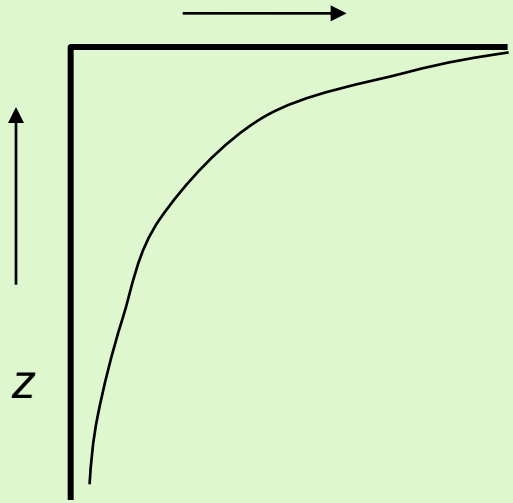


$$T_{act} = \int_{-D_{root}}^{0} S \, \partial z$$

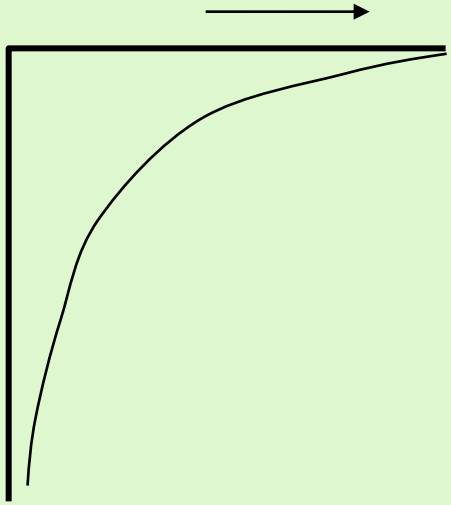


Distribution root water extraction

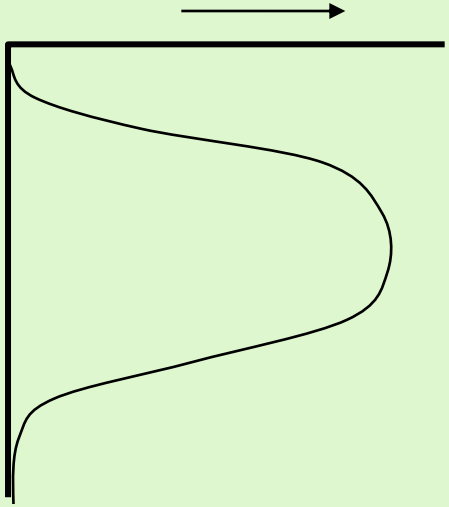
Root length density L_{root} (cm cm^{-3})



Potential root water extraction rate S_p (d^{-1})



Actual root water extraction rate S (d^{-1})

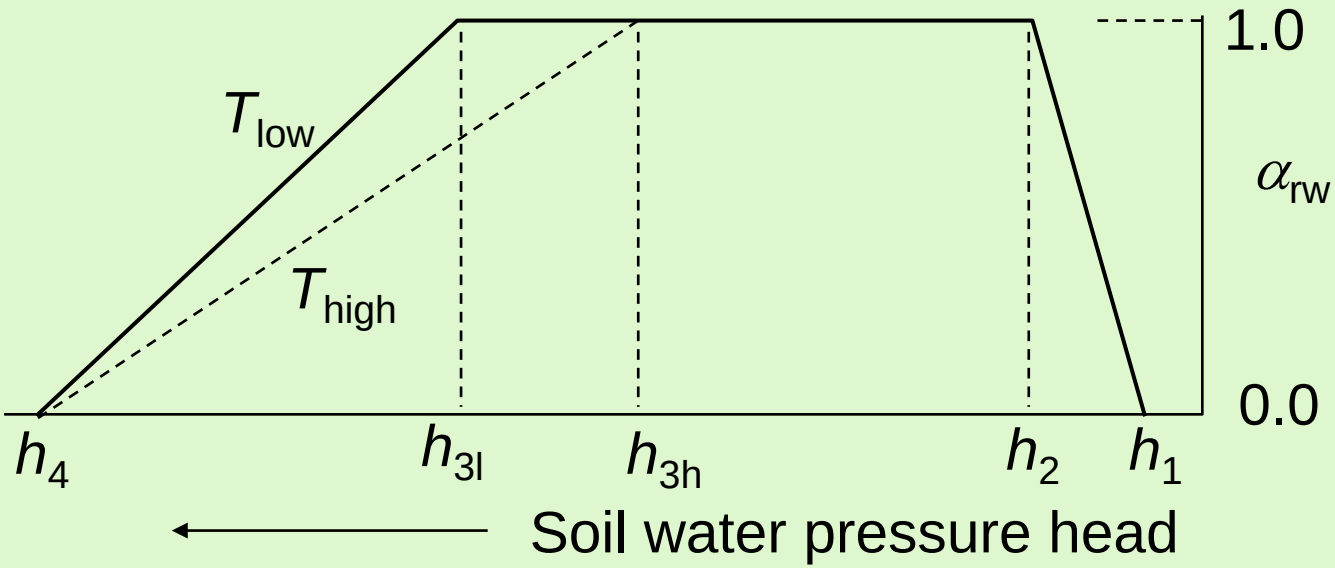


$$S_p(z) = \frac{L_{root}(z)}{\int_{-D_{root}}^{0} L_{root}(z)\,\partial z} T_p$$

$$S(z) = \alpha_{rw}\, S_p(z)$$

$$\int_{-D_{root}}^{0} S_p\, \partial z = T_p$$

Actual root water extraction

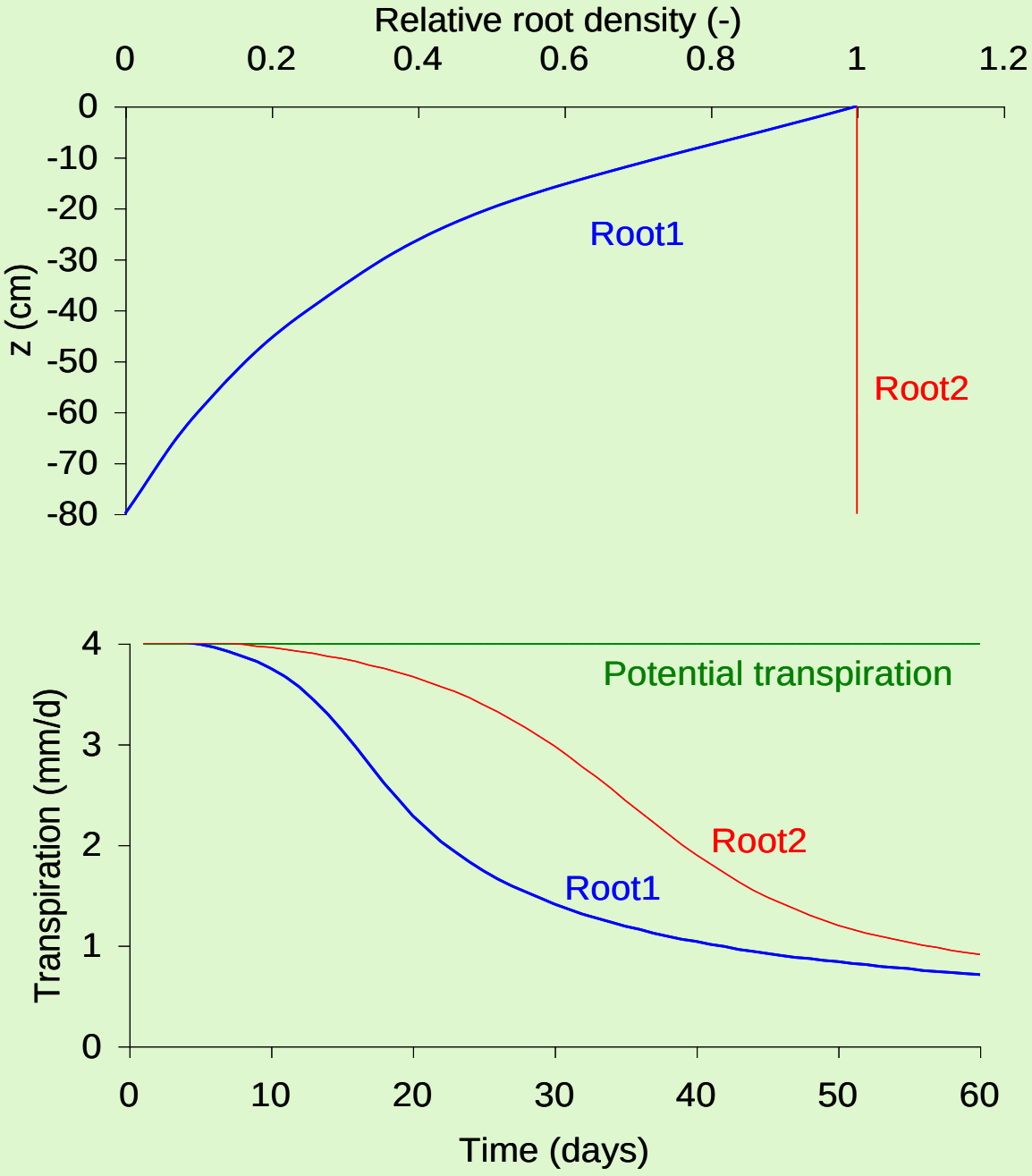


Actual root water extraction:

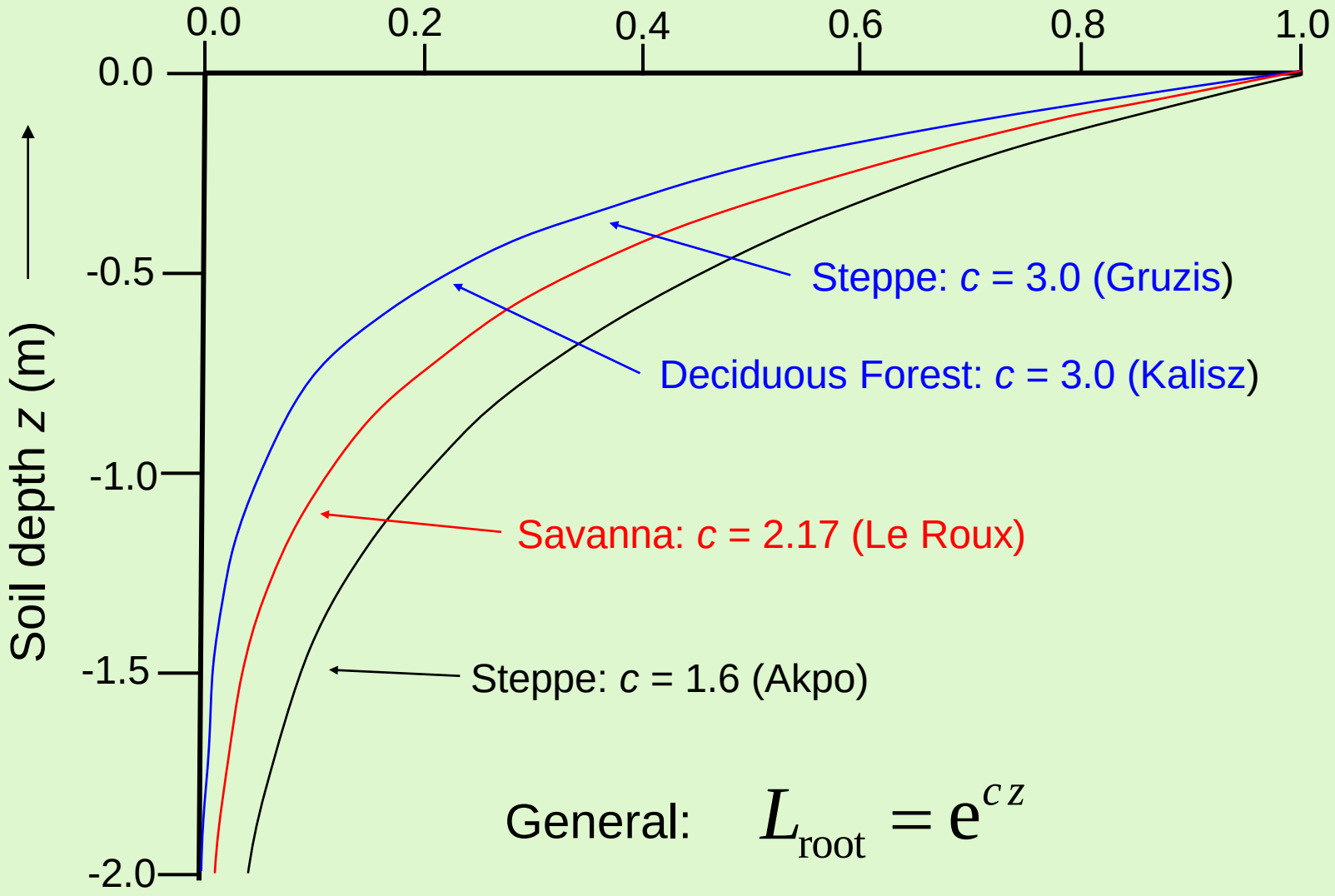
$$S(z) = \alpha_{rw} S_p(z)$$

Effect root distribution

- Grass vegetation with 100% soil cover
- Loamy sand soil (B7 and O8 in Staring Series)
- Free drainage boundary condition at z = -200 cm
- At t = 0, h = -200 cm throughout soil profile
- No rainfall, potential transpiration T_p = 4 mm d^{-1}

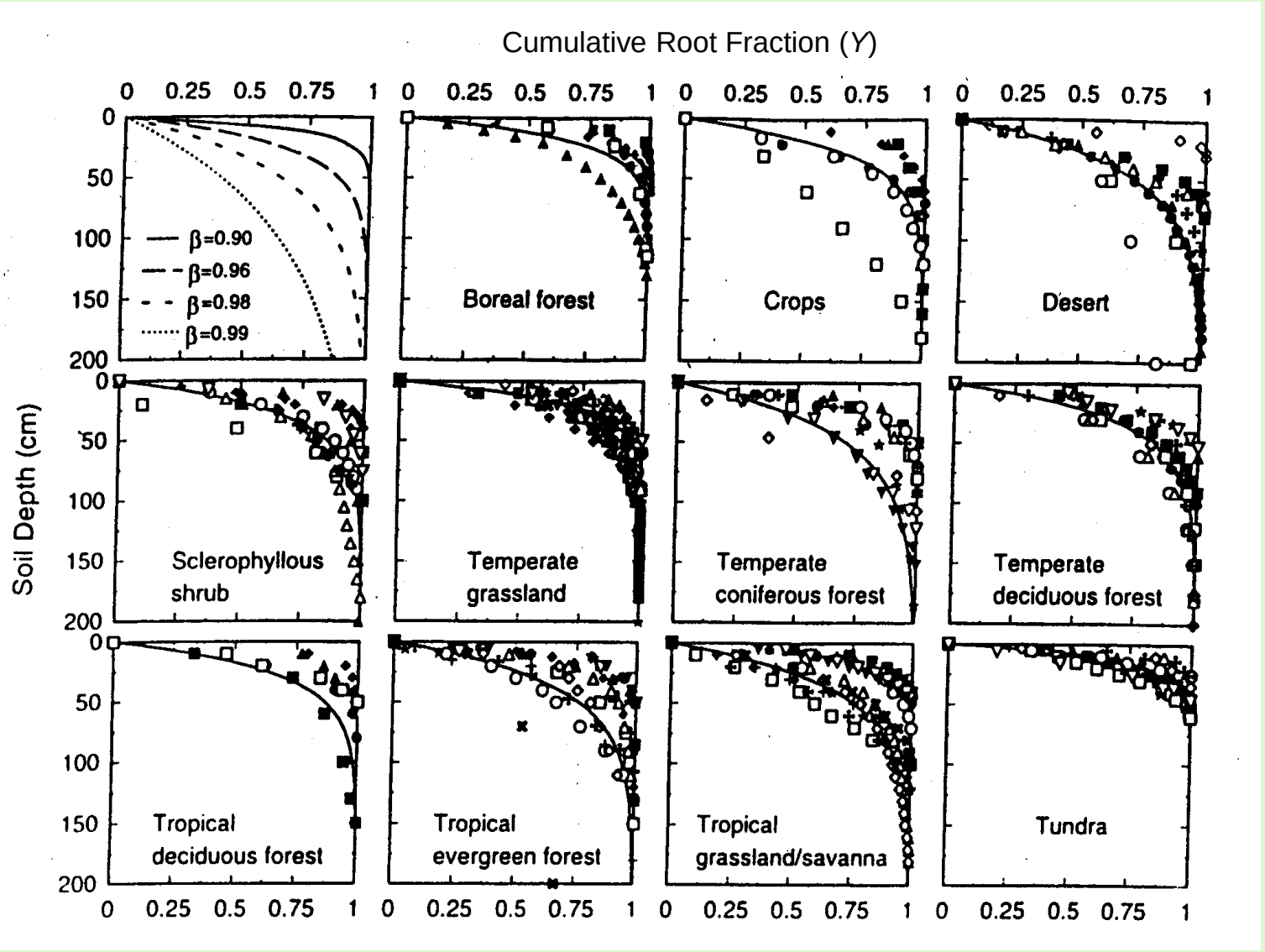

Relative root density (-)
0
0.2
0.4
0.6
0.8
1
1.2
0
-10
-20
-30
-40
-50
-60
-70
-80
z (cm)
Root1
Root2
4
3
2
1
0
Transpiration (mm/d)
Potential transpiration
Root2
Root1
0
10
20
30
40
50
60
Time (days)

Relative root density distribution



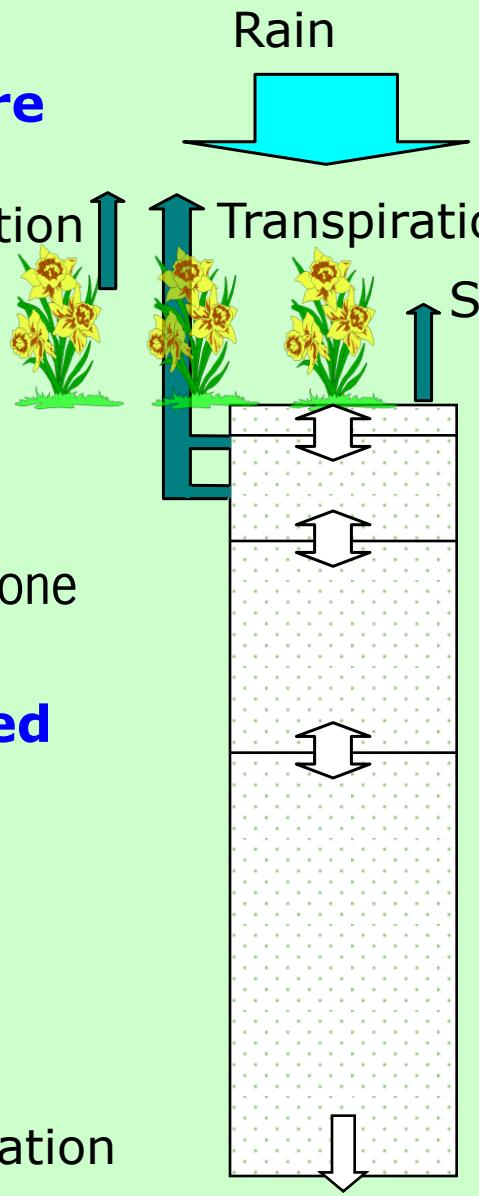
General: $L_{\text{root}} = \mathrm{e}^{c\,z}$

Cumulative root fraction



with $Y = 1 - \beta^z$

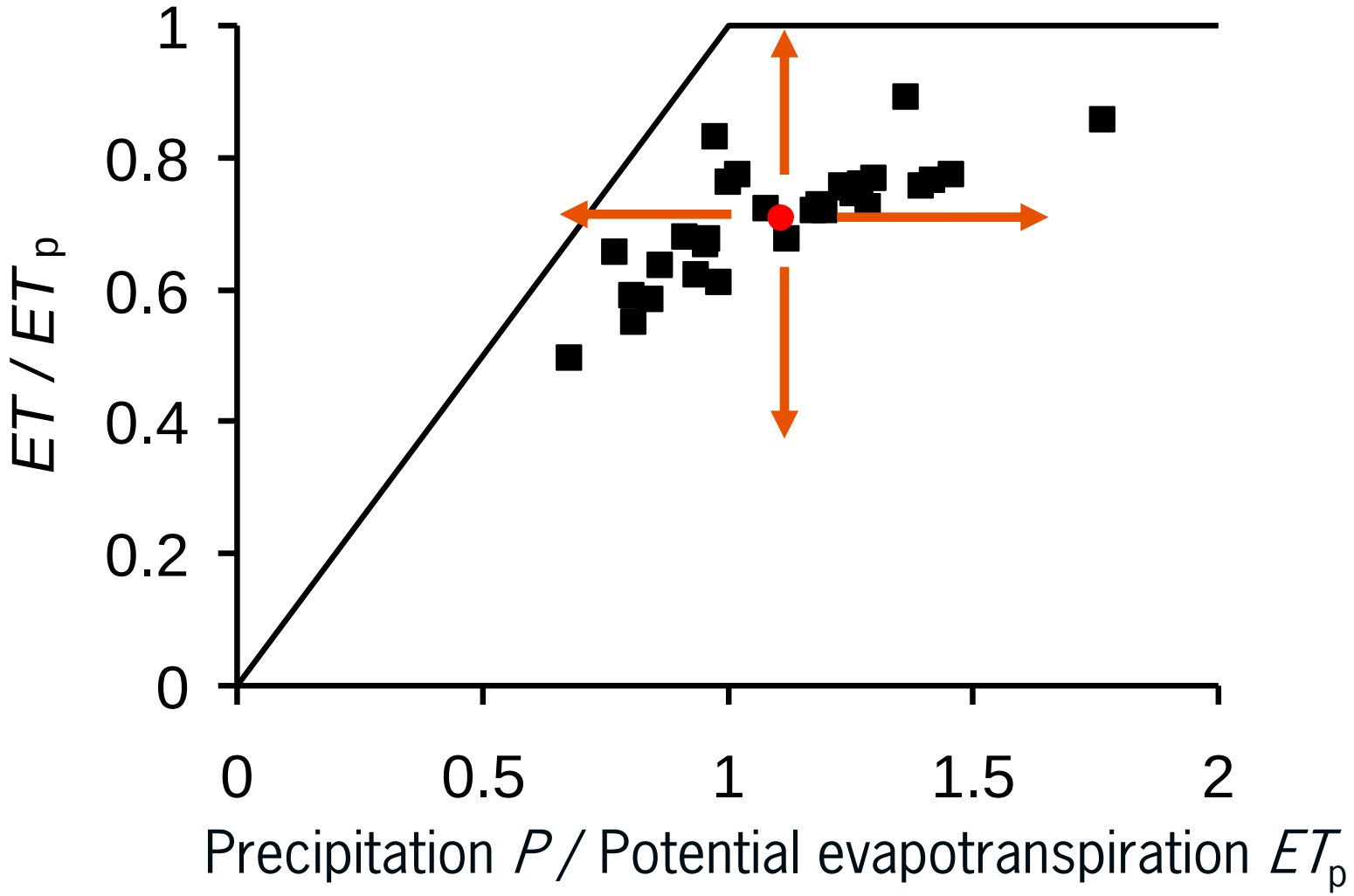
TESSEL-model for flow of water and heat



- No groundwater table is present
- Soil is homogeneous over entire depth
- Root zone: entire profile (2.89 m)
- 4 numerical layers

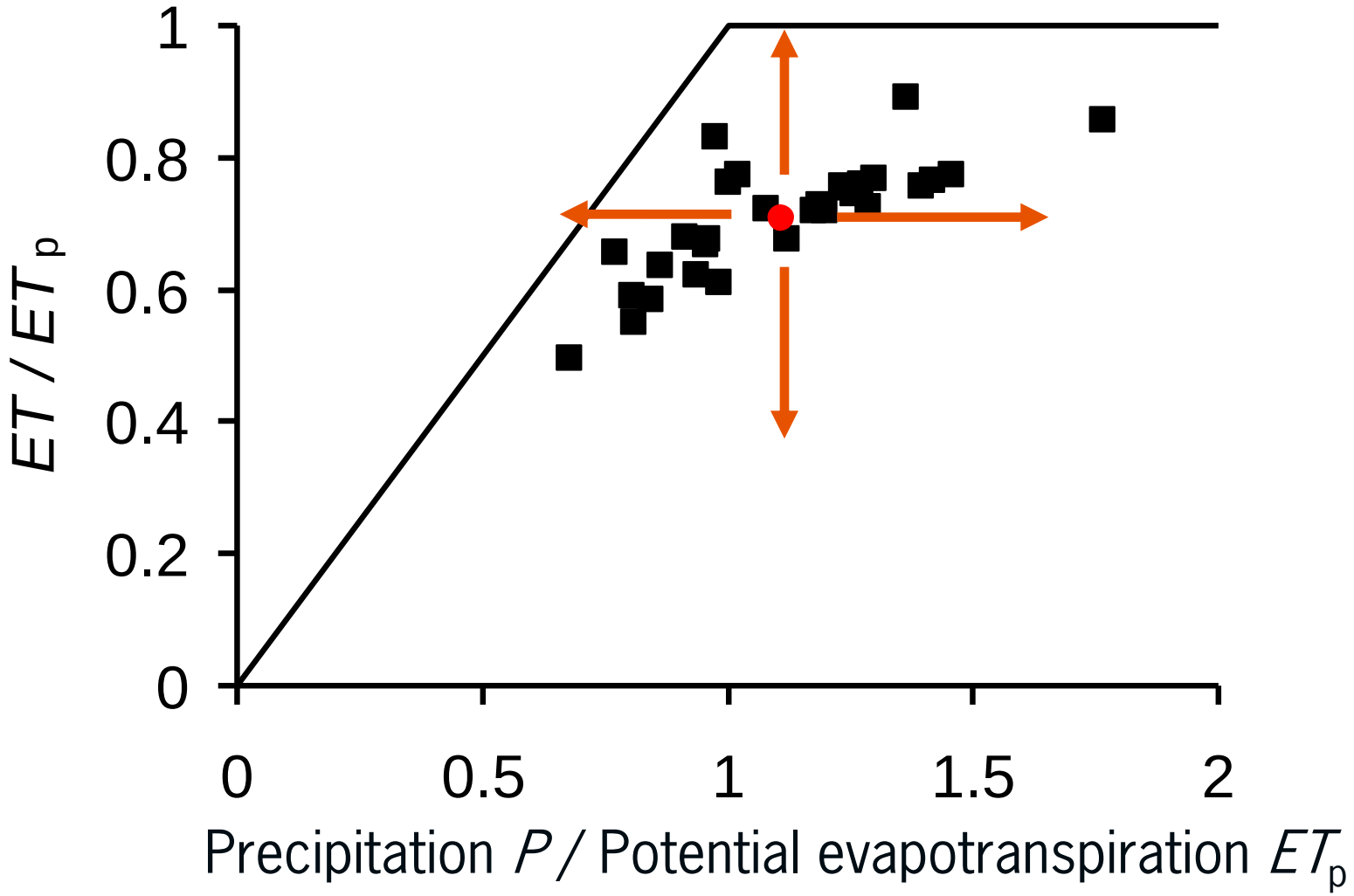
- Water management absent (no irrigation or drainage)

Possible effects of modifications on soil water balance



Groundwater dependent systems

Possible effects of modifications on soil water balance

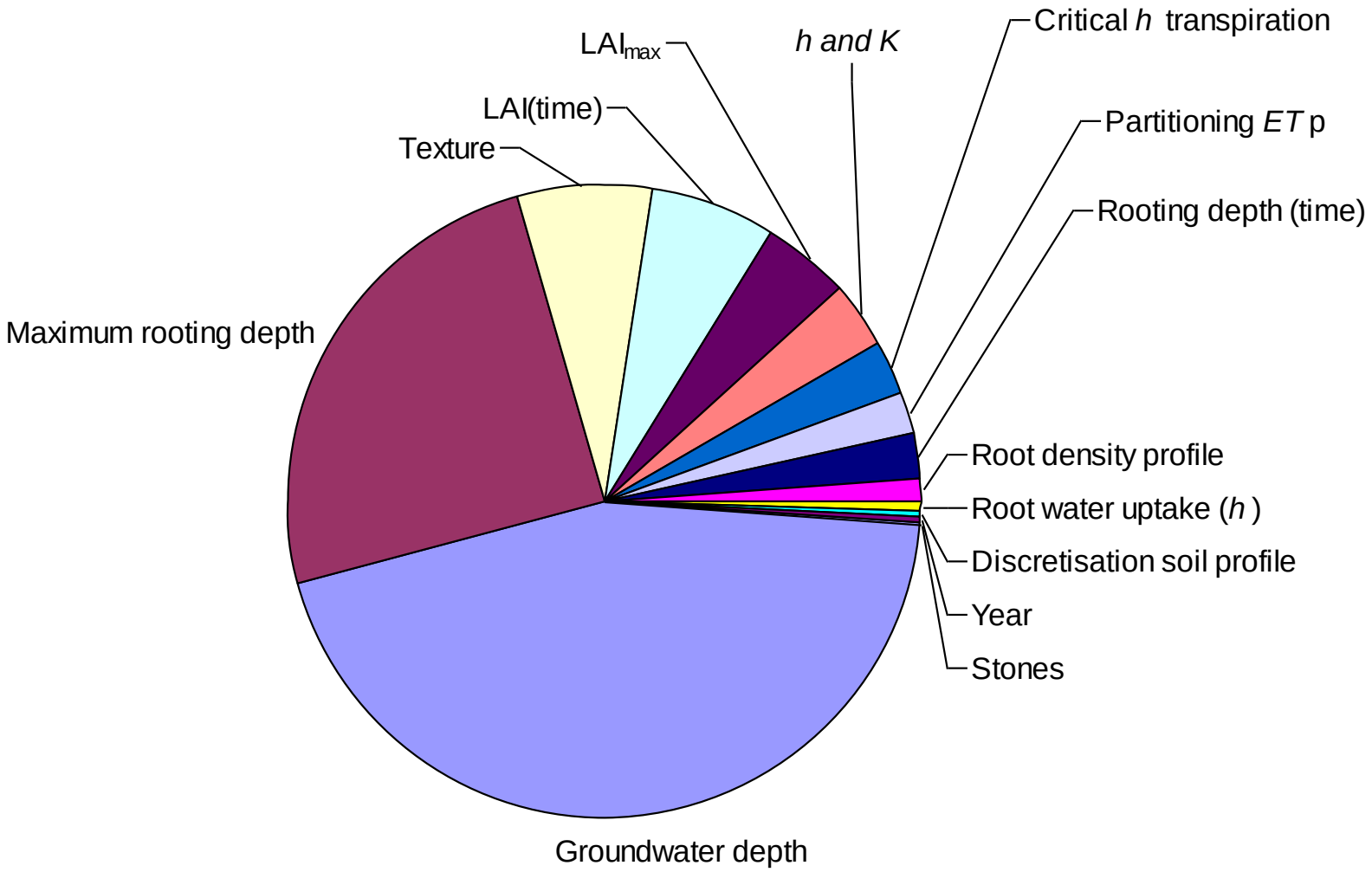


Tests with the detailed SWAP model

- Discretization
- Maximum rooting depth
- Leaf area index as a function of time
- Soil depth (shallow - deep)
- Root extraction
- Soil texture
- Bottom boundary condition (Groundwater)

Effects SWAP tests on evapotranspiration *ET*

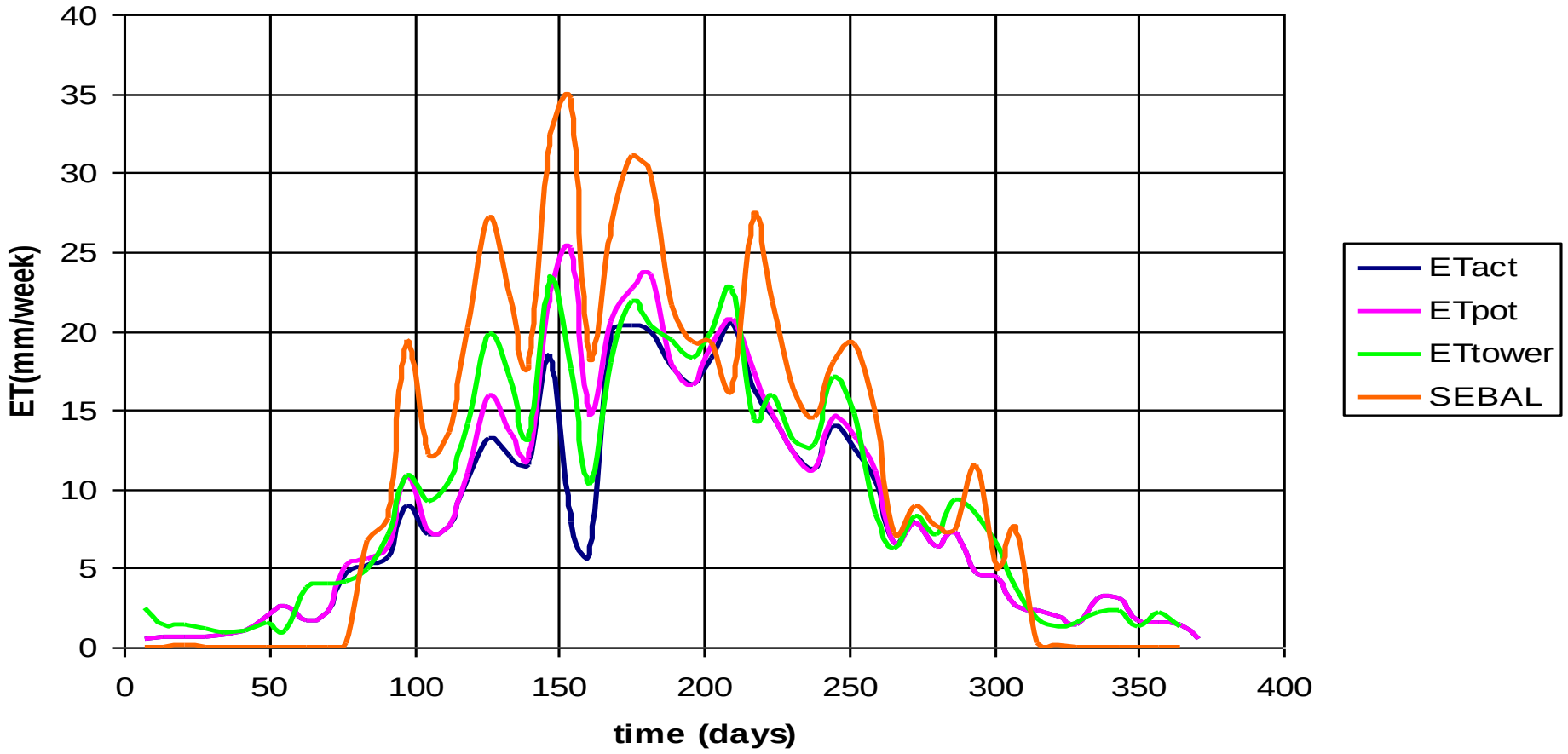
Location: Hungary – continental climate



Modifications in Tessel for Hungary

- Introduced changes
  - Discretization
  - Soil Depth
  - Groundwater
  - Root water uptake

ET- **Tower**, RS-SEBAL, [ET_{act} **and** ET_{pot}] **-SWAP**



SEBAL computations

Application of SEBAL voor 2005

SEBAL: Surface Energy Balance for Land

Basis inputs:

- Satellite based products
  - Vegetation-index (NDVI)
  - Surface albedo
  - Surface radiation temperature

- Meteorological measurements
  - Air temperature
  - Relative humidity
  - Windvelocityd
  - Transmissivitty/incoming radiation

SEBAL computations

Satellite products

Derived from the MODIS satellite

1 km resolution (thermal)

Daily recording

Total of 19 cloudfree images

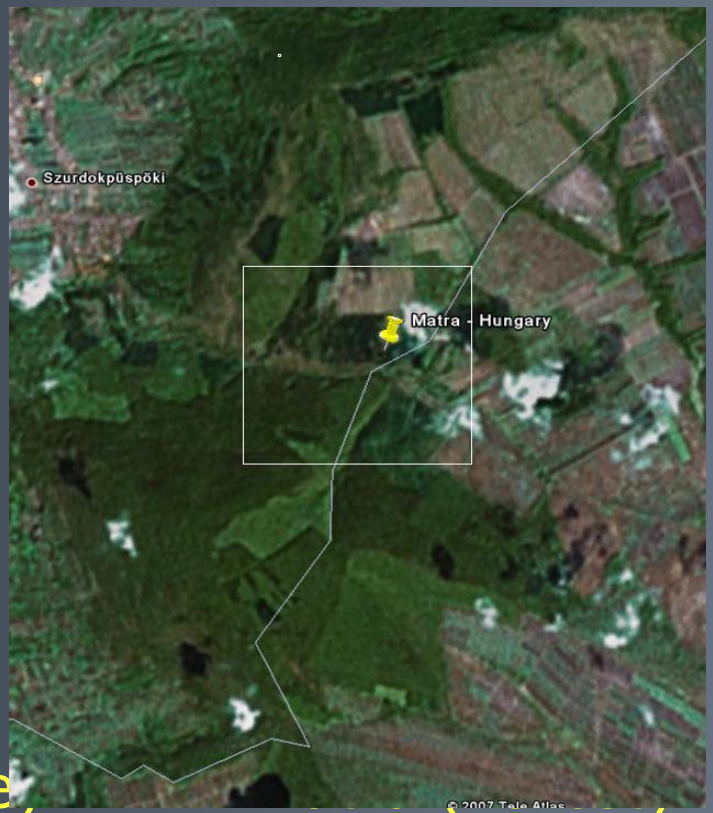
Transformed in weekly valuesof evapotranspiration for Hungary

WaterWatch

Validation

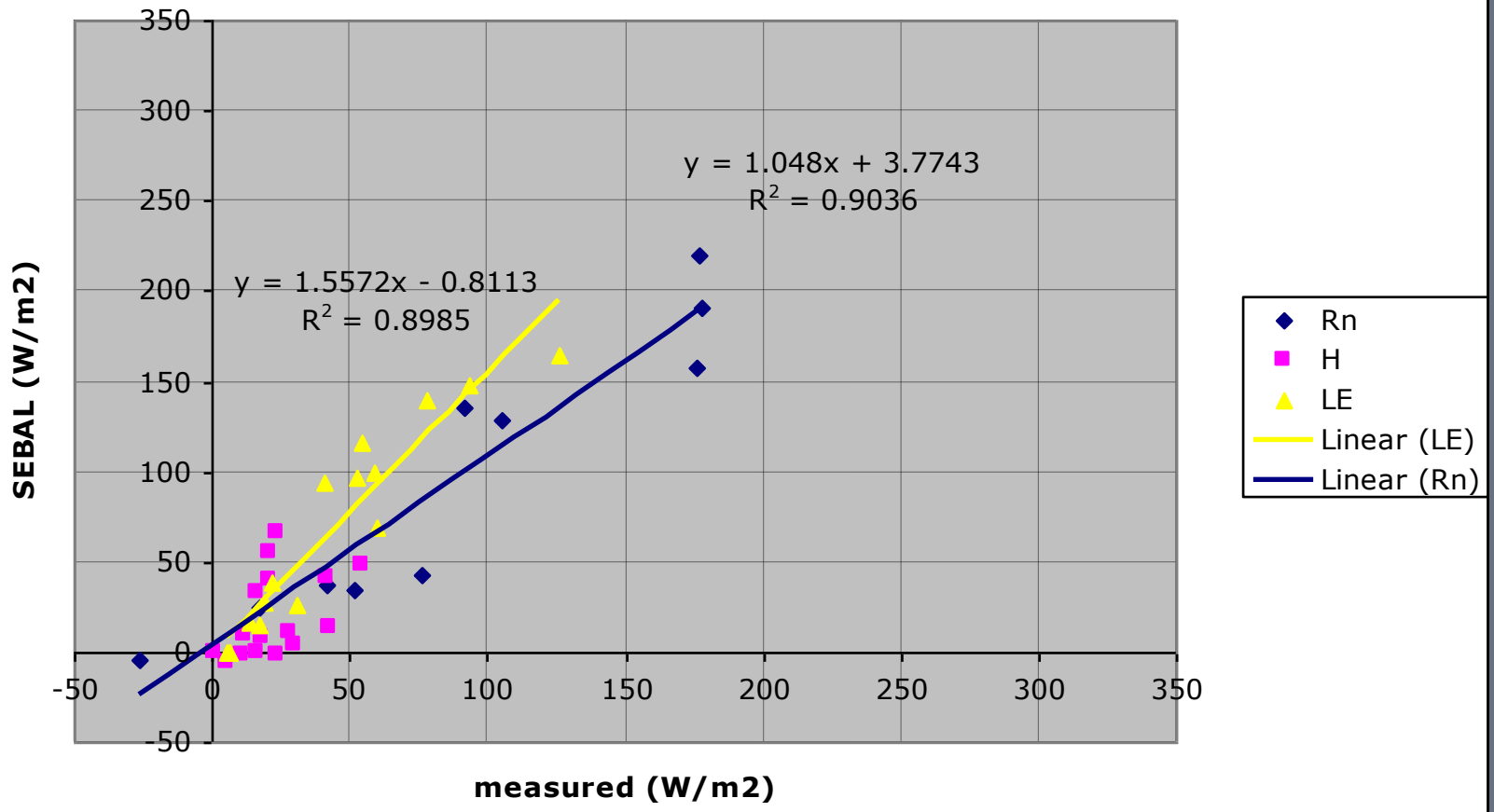
2 measuring locations in Bugac en Matra

Pixel is not homogenous!

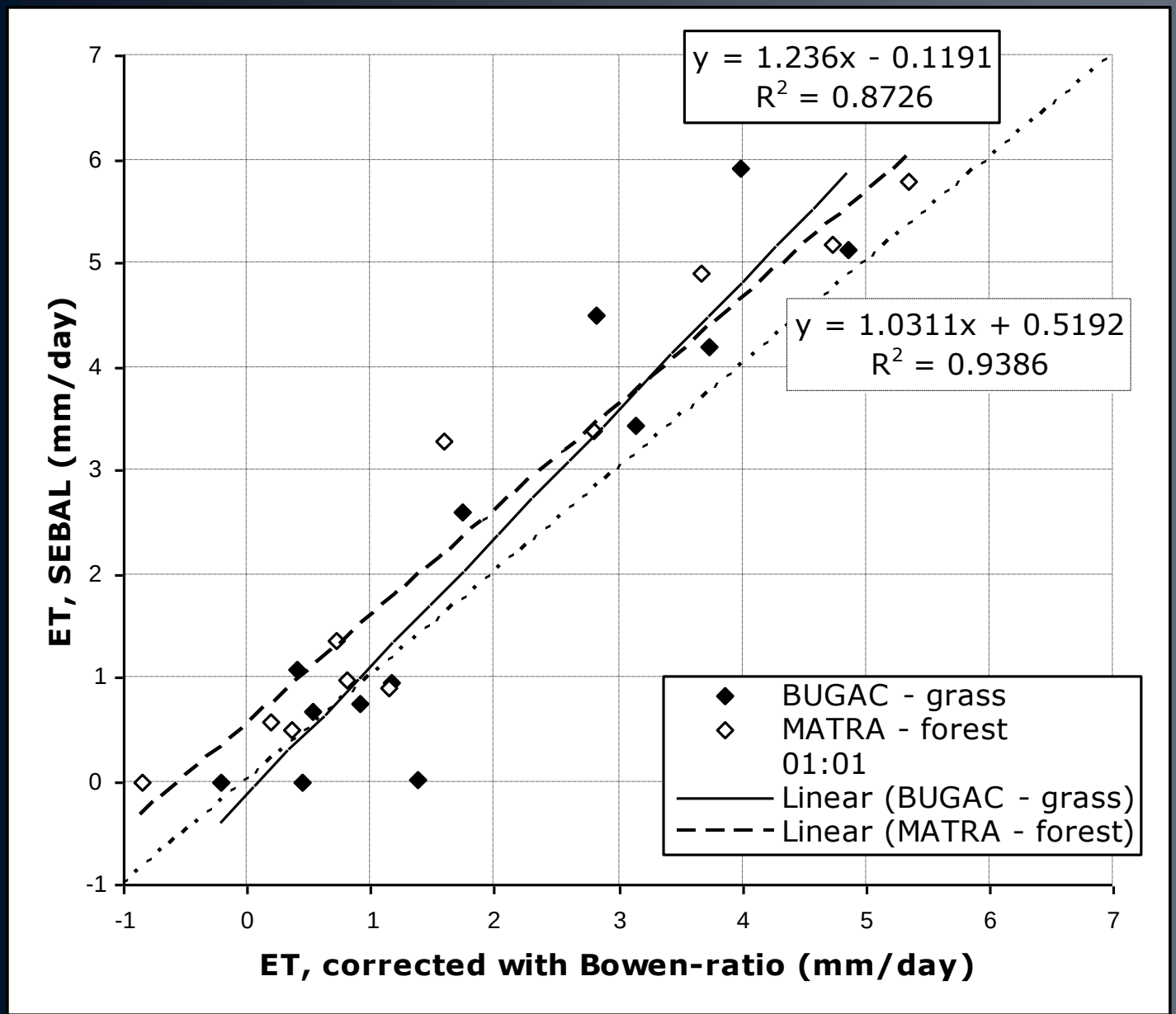


Bugac (Agriculture) (Forest)

Validation Evapotranspiration flux

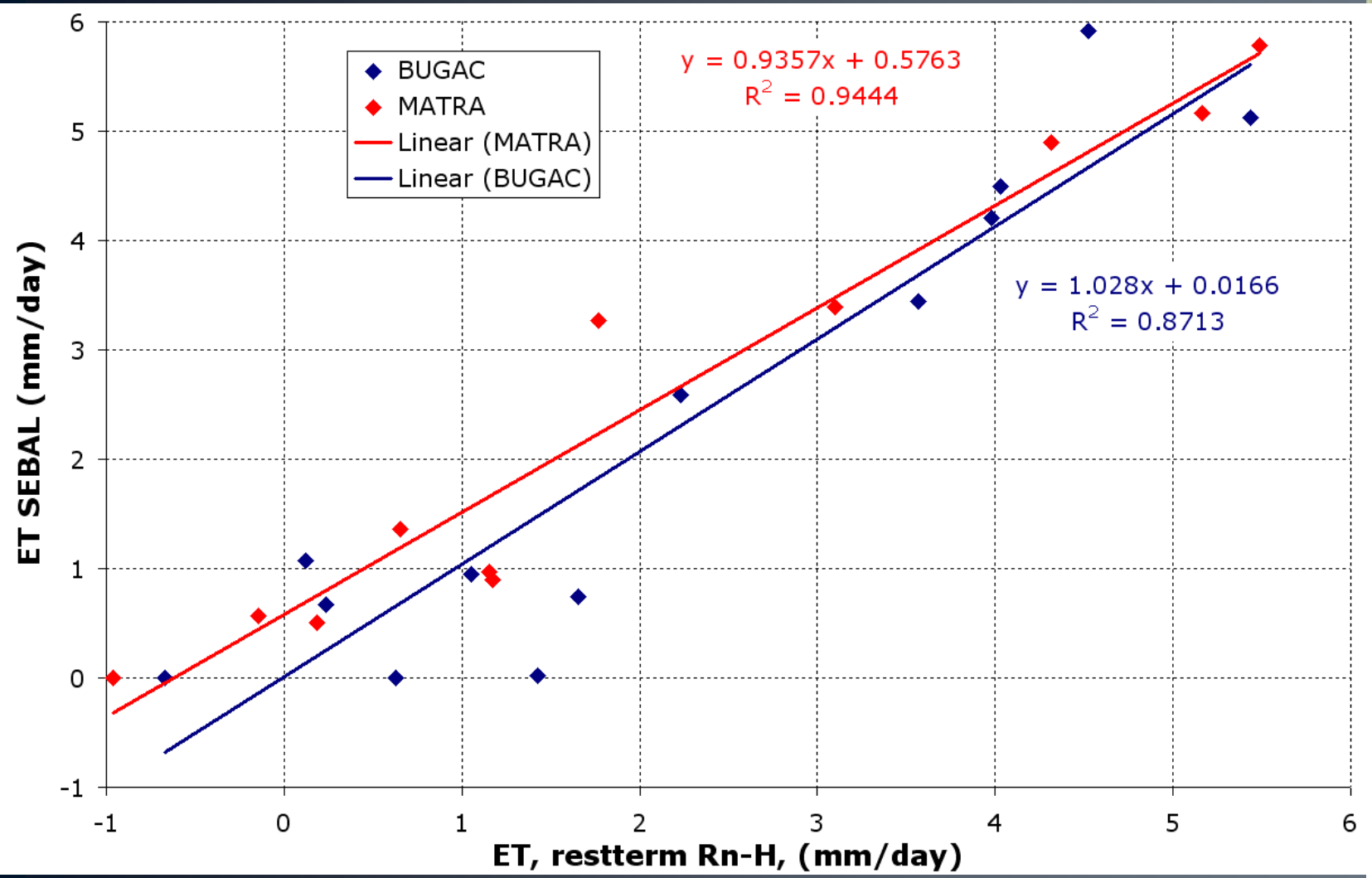


Validation fluxes with Bowen ratio



Water Watch

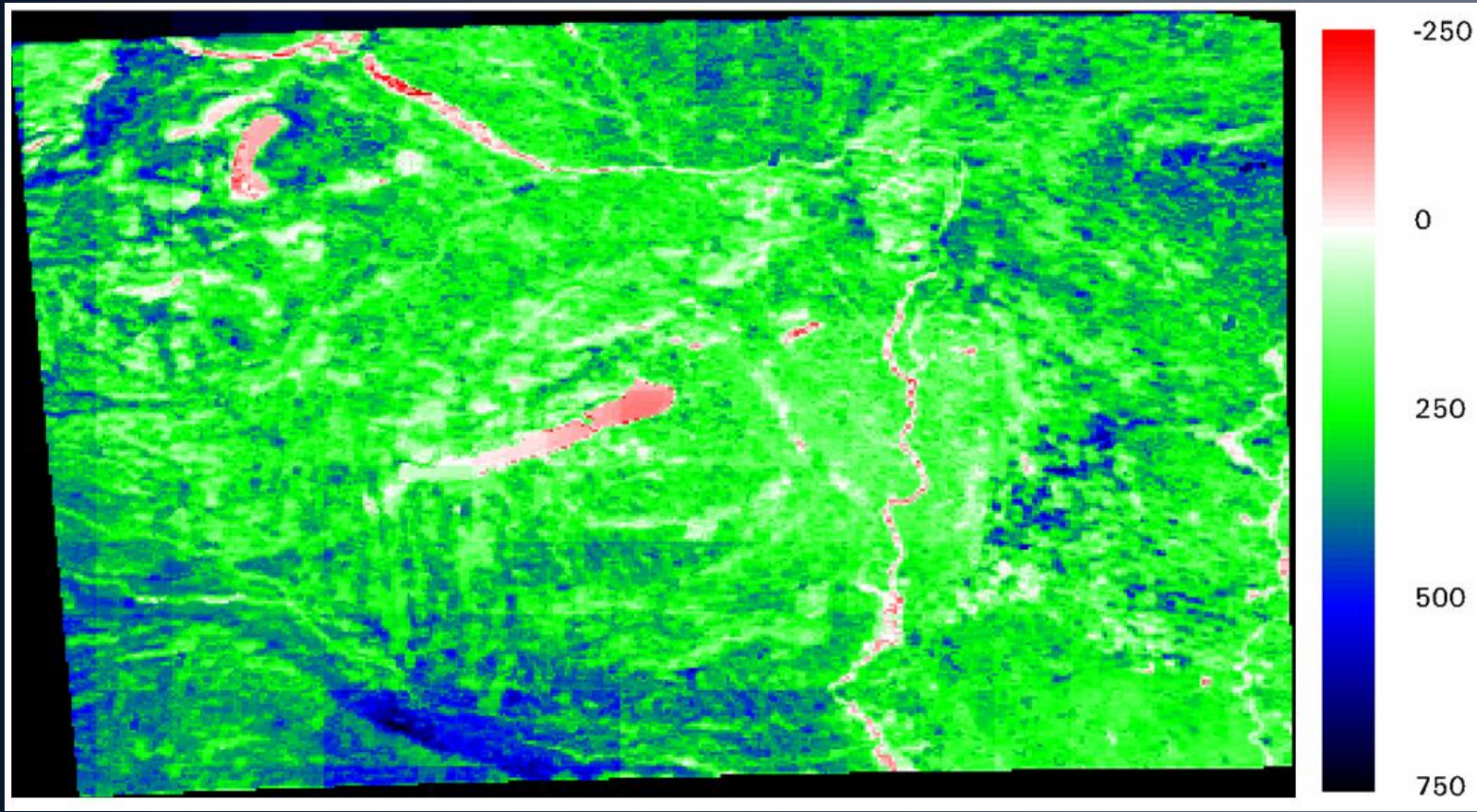
Validation with Energy balance



Water Watch

Comparison with Rainfall

Tropical Rainfall Measurement Mission (TRMM)

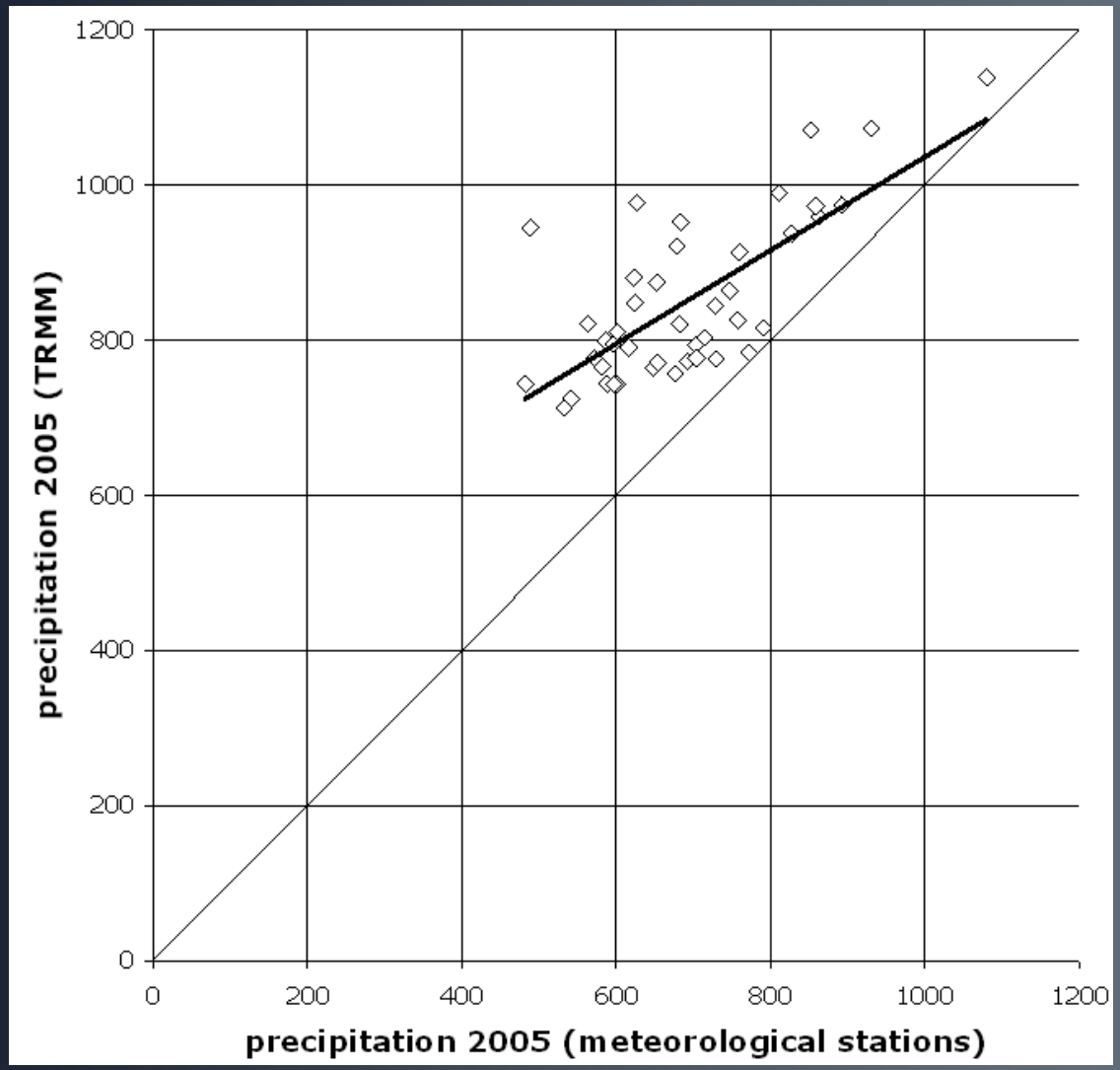


TRMM rainfall – SEBAL ET

WaterWatch

Comparison with rainfall

Tropical Rainfall Measurement Mission (TRMM) and point measurements (meteorological stations)



Conclusions

1) Measured net radiation agrees well with SEBAL estimate

2) Measured energy balance does not 'close'

3) Corrected measurements agree well with the spatial SEBAL data

4) The spatial patterns of rainfall as measured by TRMM are reflected by the evapotranspiration values computed by SEBAL