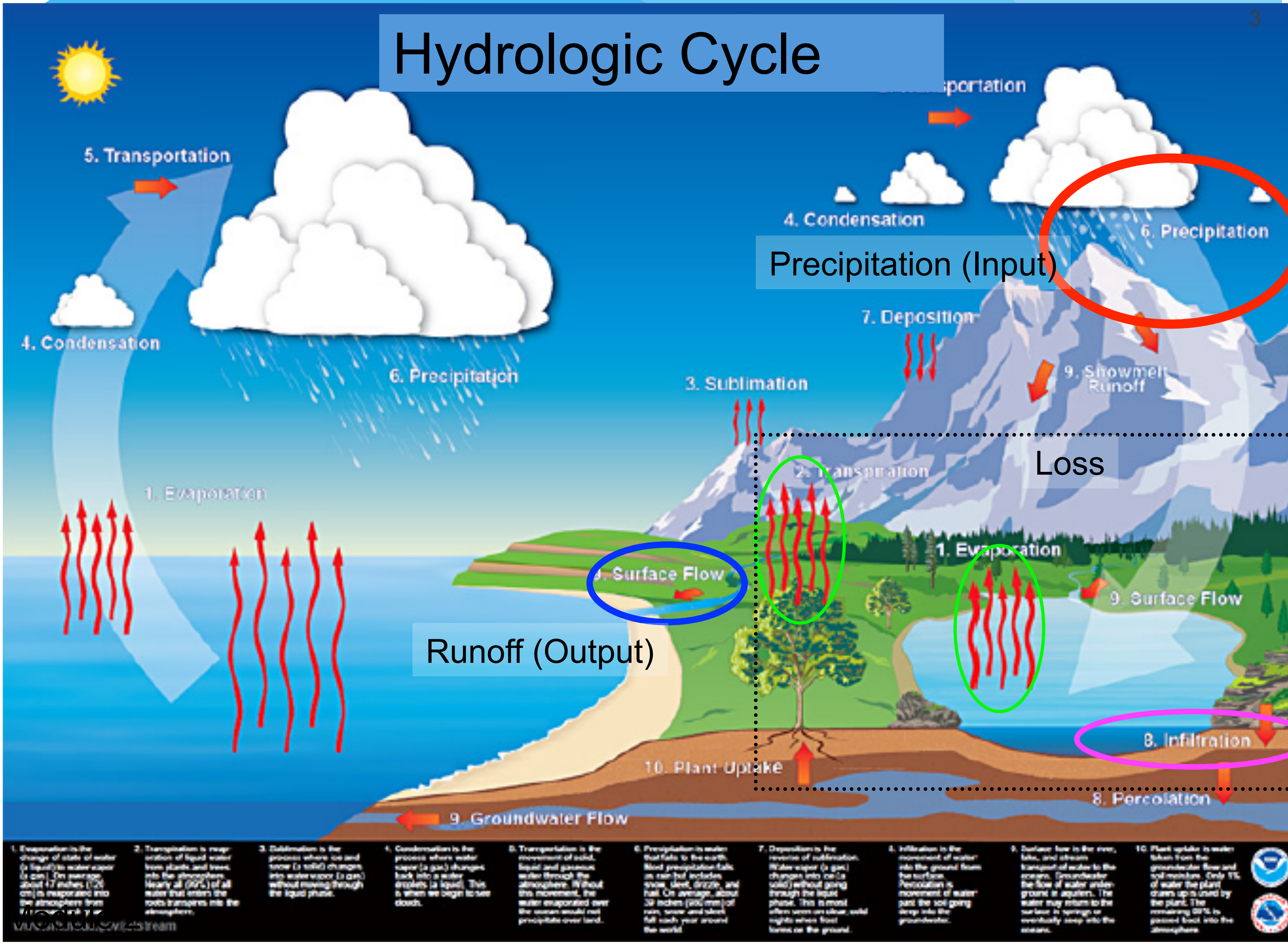
CE 3354 Engineering Hydrology

Lecture 11: Watershed Loss Processes
Evapotranspiration

Outline

- Loss Processes
  - Evapotranspiration

Hydrologic Cycle



Loss Processes – Evapotranspiration

- Process Concepts
- Useful Models:
  - Blaney-Criddle
  - Thornwaithe

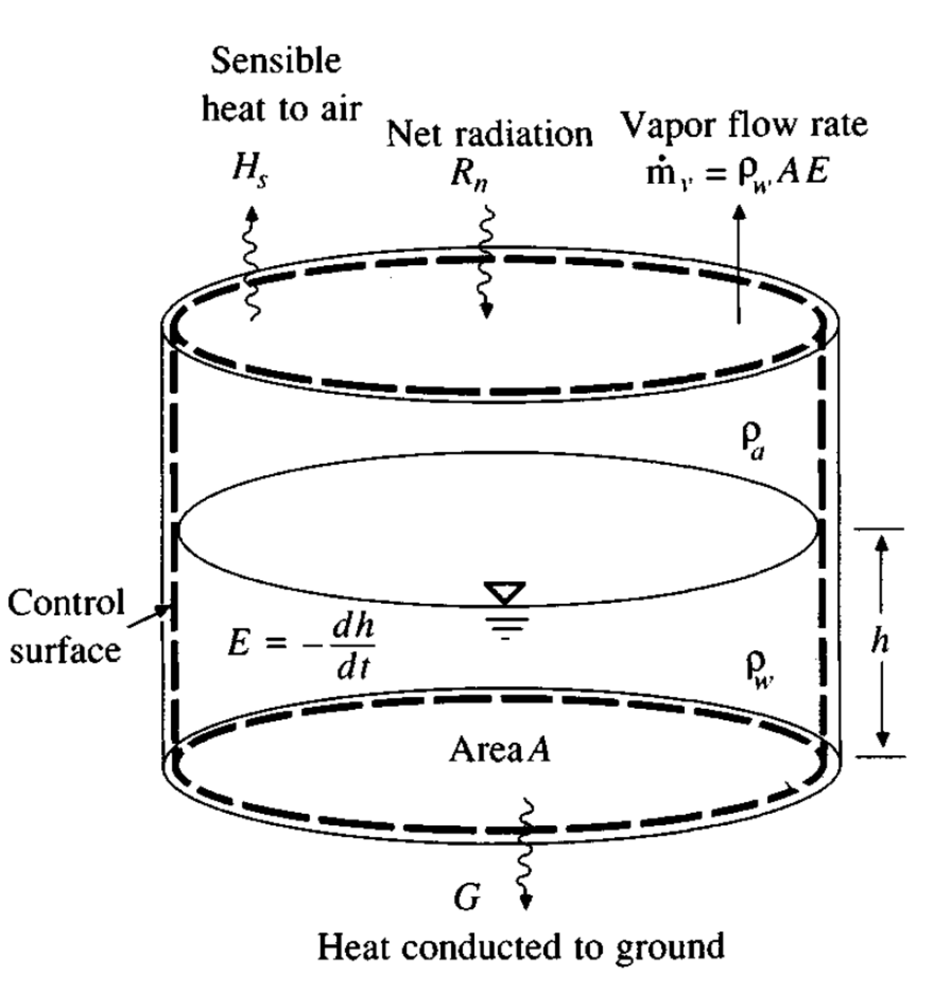
Loss Processes – Evapotranspiration

- Process Concepts
  - Heat Energy
  - Vapor transport
    - Relative humidity
    - Wind speed

The two main factors influencing evaporation from an open water surface are the supply of energy to provide the latent heat of vaporization and the ability to transport the vapor away from the evaporative surface. Solar radiation is the main source of heat energy. The ability to transport vapor away from the evaporative surface depends on the wind velocity over the surface and the specific humidity gradient in the air above it.

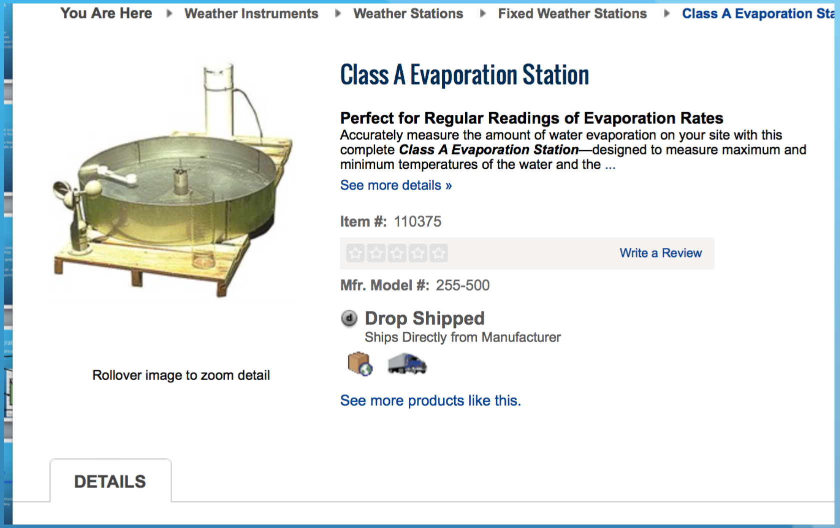
Loss Processes – Evaporation

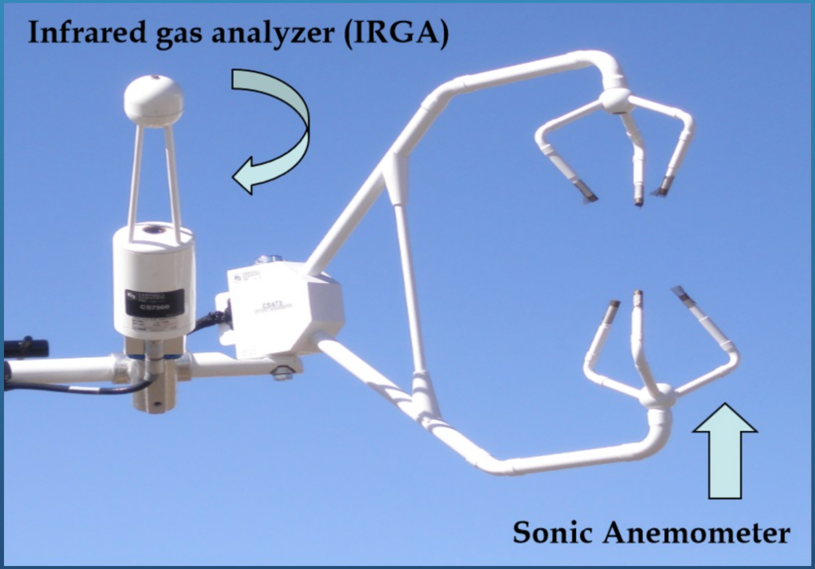
- Process Concepts
  - Thermodynamics
  - Fluid Mechanics
    - Energy Method
    - Aerodynamic Method
    - Combined Method
  - Data Requirements
    - Extensive
- CMM pp 80-91



Loss Processes – Evaporation

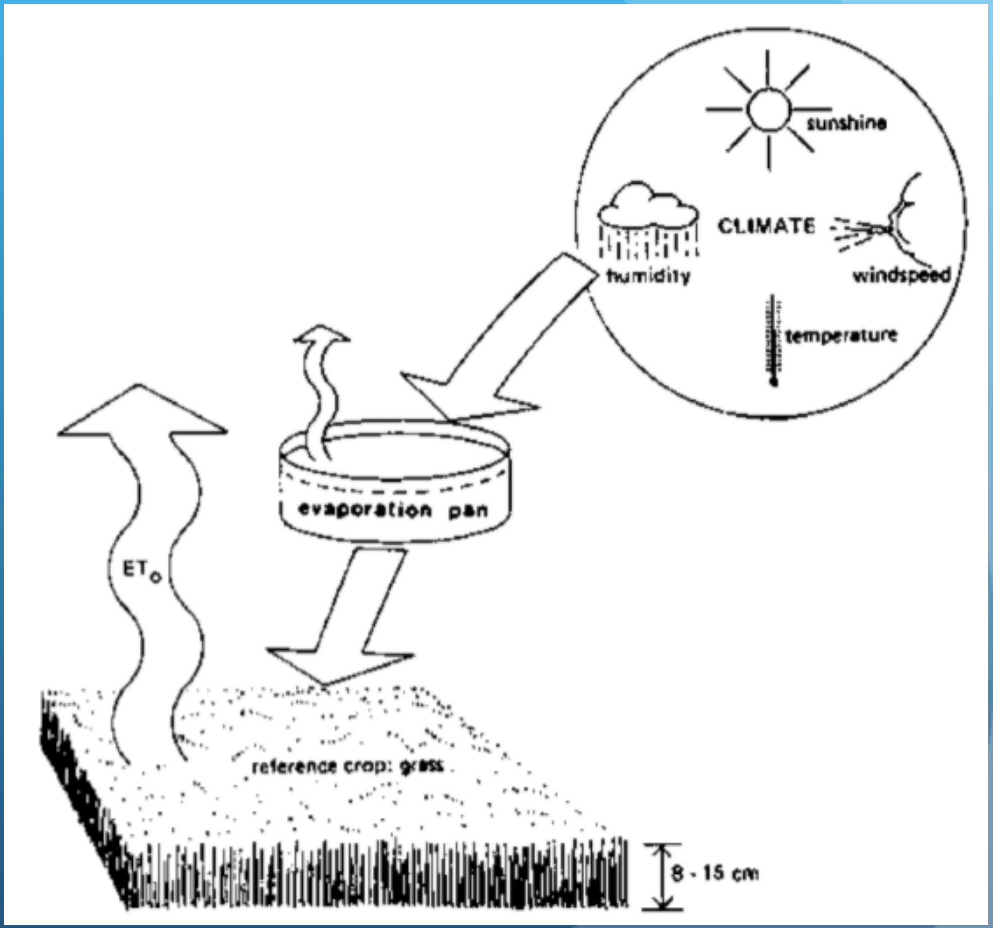
- Measurement
  - Evaporation Pans
    - Used worldwide
  - Flux Instruments
    - Eddy Covariance Instruments





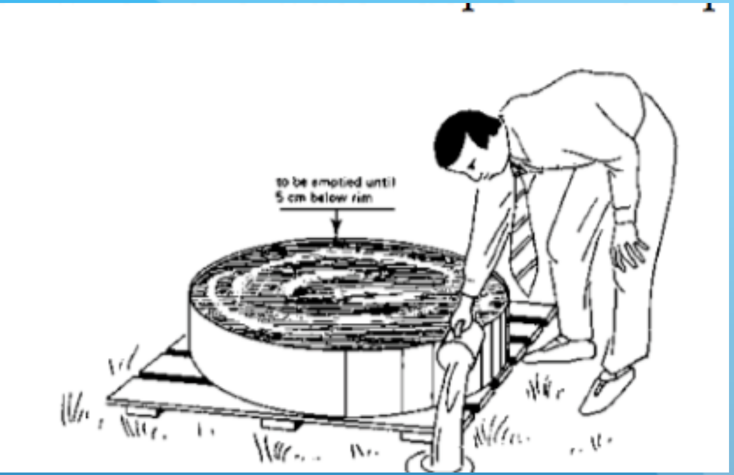
Evaporation Pans

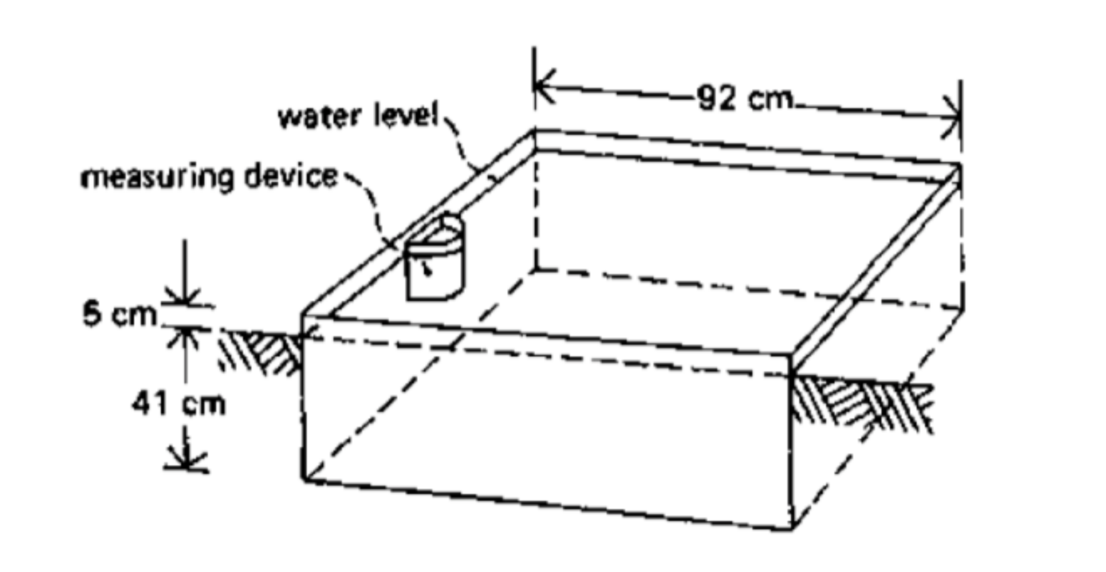
- Used in conjunction with lysimeter instruments to calibrate to crop type.
- Then make measurements with a pan or EC instrument



Evaporation Pans

- Class A - Circular.
- Colorado Sunken
  - Dug into ground, rectangular



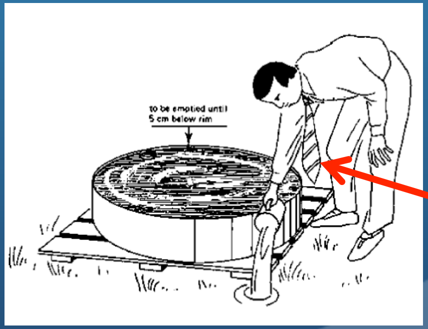


Evaporation Pan Operation (1 of 2)

- The pan is installed in the field
- The pan is filled with a known quantity of water
- The water is allowed to evaporate during a certain period of time (usually 24 hours).
  - The rainfall, if any, is measured simultaneously
- Every 24 hours, the remaining quantity of water (i.e. water depth) is measured

Evaporation Pan Operation (2 of 2)

- The amount of evaporation per time unit (the dffierence between the two measured water depths) is calculated; this is the pan evaporation: E_{pan} (in mm=24 hours)
- The E_{pan} is multiplied by a pan coecient, K_{pan}, to obtain the ET_o.
- Reset the pan for next time interval to desired level



Don't forget to dress well for the measurement.
You are a scientist/ engineer.
STEM == TIES

Pan Constants

- Need to be determined by lysimeter or Eddy Covariance instruments

Table 2: Example of Pan Evaporation measurements and calculations

Item	Value
Pan type	Class A
Water depth in pan on day 1	150 mm
Water depth in pan on day 2	144 mm
Rainfall (during 24 hours)	0 mm
K_{pan}	0.75
Formula	$ET_o = K_{pan} \times E_{pan}$
Calculation	$E_{pan} = 150 - 144 = 6mm/day$
Result	$E_o = 0.75 \times 6 = 4.5mm/day$

Evapotranspiration – Models

- Models are used to estimate ET for practical cases where measurements are not available
  - Blaney-Criddle
  - Turk
  - Thornwaithe
- All similar in that they are correlations to averaged measurements at different locations
- All are just approximations, but are used in practice and when ET matters they may be only tool available

Blaney-Criddle Model

- Simple formula – Temperature and latitude driven only!
  - Estimates daily rate for a particular month

$$ET_o = p\,(0.46\ T_{mean} + 8)$$

  - Temperature is an average from daily values for a month

$$T_{max} = \frac{\sum T_{max\ \ daily}}{days}$$

$$T_{min} = \frac{\sum T_{min\ \ daily}}{days}$$

$$T_{mean} = \frac{T_{max}+T_{min}}{2}$$

Blaney-Criddle Model

- P- value by latitude and month

Table 4: Blaney-Criddle p values by latitude

Lat (N)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lat (S)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
60	.15	.20	.26	.32	.38	.41	.40	.34	.28	.22	.17	.13
55	.17	.21	.26	.32	.36	.39	.38	.33	.28	.23	.18	.16
50	.19	.23	.27	.31	.34	.36	.35	.32	.28	.24	.20	.18
45	.20	.23	.27	.30	.34	.35	.34	.32	.28	.24	.21	.20
40	.22	.24	.27	.30	.32	.34	.33	.31	.28	.25	.22	.21
35	.23	.25	.27	.29	.31	.32	.32	.30	.28	.25	.23	.22
30	.24	.25	.27	.29	.31	.32	.31	.30	.28	.26	.24	.23
25	.24	.26	.27	.29	.30	.31	.31	.29	.28	.26	.25	.24
20	.25	.26	.27	.28	.29	.30	.30	.29	.28	.26	.25	.25
15	.26	.26	.27	.28	.29	.29	.29	.28	.28	.27	.26	.25
10	.26	.27	.27	.28	.28	.29	.29	.28	.28	.27	.26	.26
5	.27	.27	.27	.28	.28	.28	.28	.28	.28	.27	.27	.27
0	.27	.27	.27	.27	.27	.27	.27	.27	.27	.27	.27	.27

Next Time

- Loss Processes
  - Evapotranspiration