Gupta Prob. 2.24

Energy Balance to calc ET

In [15]:
```
import quantities as un
from math import sqrt
un.MJ = un.UnitQuantity('megajoule', un.joule*1e6, symbol='MJ')
Bowen=0.1
noverN=0.85 # cload cover
tempAir=23*un.celsius
tempAirK=(23+273.2)*un.kelvin
H=.47 #humidity
R_A=42.5*un.MJ*un.m**-2*un.day**-1
albedo=0.08
sigma=1.*un.constants.sigma #stefan-boltzman constant
sigma.units='MJ*m**-2*kelvin**-4*day**-1'
latHeatVap=2.447*un.MJ*un.kilogram**-1
densWater=1000*un.kg*un.m**-3
print 'sigma=',sigma
```

```
sigma= 4.8992256e-09 MJ/(m**2*d*K**4)
```

Short wave radiation (Sn) is used for heat. Only a portion of radiation reaches ground as short wave radiation. Some is blocked by material in atmosphere (eg. clouds), and some short wave radiation is reflected back (surface albedo). An empirical relationship relating these factors is (Eqn 2.24):

$$S_n = (1-\alpha)(.25 + .5\,\frac{n}{N})R_A$$

In [16]:
```
Sn=(1-albedo)*(0.25+0.5*noverN)*R_A
print 'Sn=',Sn
```

```
Sn= 26.3925 MJ/(m**2*d)
```

In [17]:
```
#based on vap. press. in append, slightly different from value in Table 2.9
e_d=H*((23-20)/(25.-20)*(3.169-2.337)+2.337)*un.kPa
print e_d
```

```
1.333014 kPa
```

Black body radiation emmitted from ground and atmosphere (clouds, water vapor) is emitted as long wave radiation. This is negative here, indicating loss of energy from the ground due to re-radiated long wave energy. Black body radiation is controlled by the Stefan-Boltzmann Eqn.

$$R_{SB} = \sigma T^4$$

Tthe re-radiated energy is influenced by cloud cover and moisture vapor the traps the energy near the ground. Gupta cites and empirical relationship to calculate this (Eqn 2.26):

$$R_b = -(.1 + .9\,\frac{n}{N})(.34 - .14\sqrt{e_d})\sigma T^4$$

Net energy gained by system is the short wave energy coming in less the long wave radiation leaving the system. The 'lost' energy is assumed to be used to vaporize water.

$$E_r = \frac{R_n}{\lambda \cdot \rho_w \cdot (1+\beta)}$$

The energy driving evaporation and sensible heat flux is derived from the incoming short wave radiation and outgoing black body radiation ($S_n + R_b$)

In [18]:
```
R_b=-(0.1+0.9*noverN)*(0.34-0.14*sqrt(e_d))*sigma*tempAirK**4

print 'R_b=',R_b

R_n=Sn+R_b

print 'R_n=',R_n

E_r=R_n/(latHeatVap*densWater*(1+Bowen))

print 'E_r=',E_r
```

```
R_b= -5.81814249422 MJ/(m**2*d)
R_n= 20.5743575058 MJ/(m**2*d)
E_r= 0.0076436294928 m/d
```