Environmental Modeling
Homework #7
Due on Thursday, December 6, 2012

One week hourly meteorological data collected at the USDA SCAN site GA2027 (31°30′N, 83°33′W) in Georgia can be downloaded at the class' website:
http://geography.unt.edu/~fpan/phtml/geog5400_fall2012.html

The data file is called week2.txt with 18 columns:

Column 1 = month
Column 2 = day
Column 3 =year
Column 4= hour
Column 5=downward solar radiation (W/m^2)
Column 6= air temperature at 2 m (°C)
Column 7 = relative humidity at 2 m (%)
Column 8 = wind speed at 2 m (m/s)
Column 9= ground temperature at 5 cm below surface (°C)
Column 10= ground temperature at 10 cm below surface (°C)
Column 11= ground temperature at 20 cm below surface (°C)
Column 12= ground temperature at 50 cm below surface (°C)
Column 13= ground temperature at 100 cm below surface (°C)
Column 14= soil moisture at 5 cm below surface (%)
Column 15= soil moisture at 10 cm below surface (%)
Column 16= soil moisture at 20 cm below surface (%)
Column 17= soil moisture at 50 cm below surface (%)
Column 18= soil moisture at 100 cm below surface (%)

1. Write an implicit energy balance model for this site starting from surface down to 100 cm with a depth interval of 0.05 m (dz=0.05m) and a time step of one hour (dt=1hr=3600sec).

2. Use the following conditions and parameters to solve ground temperatures at n=1:19 layers (i.e., z= 5 cm : 95 cm) at each hour from time = 1 hr to time=168 hr:

(1) The initial condition at each depth is given based on the measurements of ground temperatures at 5 cm, 10 cm, 20 cm, 50 cm, and 100 cm.

(2) The lower boundary condition is given using the ground temperatures measured at 100 cm.

(3) The surface albedo is 0.2 and the surface emissivity is 0.95.

(4) Assume the atmospheric emissivity is constant during this period and is equal to 0.99.

(5) The site is bare ground, the surface roughness height z_o=0.01m, the zero-plane displacement height z_d=0m, and z_m=2m.

(6) The Stefan-Boltzman constant $\sigma=5.67\times10^{-8}$ W/($m^2 \times K^4$) and the latent heat of vaporization $\lambda=2.5\times10^6$ J/kg.

(7) The air density ρ_a=1.22 kg/m3

(8) The air thermal capacity c_a=1005 J/(kg × K)

(9) The soil thermal conductivity k_s=1.05 J/(m × s × K)

(10) Soil volumetric thermal capacity $\rho_s c_s$ =1.47×10^6 J/(m^3×K)

(11) Assume air pressure is at P=101.3Kpa.

(12) The site is sandy soil, the field capacity is 9.1%, and residual soil moisture content is 2.0%.

3. Plot the observed and simulated ground temperatures at 5 cm, 10 cm, 20 cm, and 50 cm.

4. Compute the root mean square error (RMSE) and correlation coefficient between the observed and simulated ground temperatures at 5 cm, 10 cm, 20 cm, and 50 cm.