Physical Climatology: Principles

November 11, 2000 Field class

Exercises on the evaluation of energy and mass fluxes in the surface boundary layer, on instrumentation for energy flux measurements, and on climates of vegetated surfaces.

1. Describe the instrumentation need for turbulent energy flux measurements (sensible, latent) based on the gradient method, for radiation balance, and for ground heat flux.

2. What is the Richardson Number and why do we use a stability function for the derivation of convective fluxes?

3. In the following two different sets of measurements are given.

   a) Calculate the Richardson Number for both cases.
   b) Plot the temperature and wind profile on semi-logarithmic paper; e.g., log(z) versus T and V.
   c) Derive the roughness length for both data sets (use plot of log(z) versus V)
   d) Discuss the two profiles in the context of the atmospheric stability.
   e) Derive the radiation balance and the albedo from the two date sets.
   f) Calculate the sensible and latent heat flux for both data sets and use the stability function if needed. To derive the vapor pressure from the measured relative humidity use the following approximation:

      Relative Humidity = $100\ (e/e_s)$

      vapor density $\rho = 2.17\ e / T$; e[Pa], T[K]

      e = vapor pressure

      e_s = saturation vapor pressure

      P = pressure

      $Q_H=[-C_a k^2(\Delta u\ \Delta T)/(\ln(z_2/z_1))^2]$ X

      C_a : heat capacity of the air = $0.0012\ 10^6$ J m^{-3} K^{-1}

      $Q_E=[-L_v k^2(\Delta u\ \Delta\ \rho)/(\ln(z_2/z_1))^2]$ X

      L_v : latent heat of vaporization = $2.52\ 10^6$ J kg^{-1}

      X: factor stable condition = $(1\text{-}5\ Ri)^2$

      X: factor unstable condition = $(1\text{-}16\ Ri)^{3/4}$

   g) Derive the ground heat flux as residual of the above calculated energy balance.
   h) Calculate the Bowen ratio for both case studies.

Instruments heights: Level 1= 0.2 m; level 2 = 0.6 m; level 3 = 1.3 m

JD_time	Net R.	S(refl)	S(in)	V1	V2	V3	DIR	T1	T2	T3	H1	H2	H3	P
	W/m^2	W/m^2	W/m^2	ms^{-1}	ms^{-1}	ms^{-1}	Deg.	C	C	C	%	%	%	mb
303.5521	36.35	199.08	273.81	.97	1.43	1.65	58.	-7.7	-8.0	-8.3	76.0	82.6	87.7	835.66
306.8542	-58.67	.00	.00	.88	1.11	1.35	316.	-13.0	-12.2	-11.7	68.9	67.5	65.7	836.26

V: wind speed H: relative humidity P: pressure
Net R.: net radiation S(refl).: short-wave reflected radiation S(in): short-wave incoming radiation