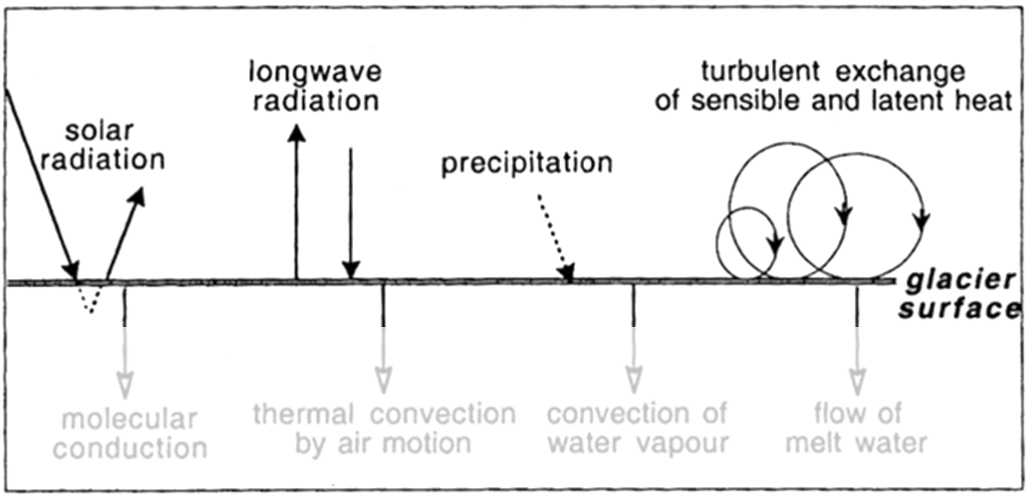
Surface energy balance

Supplemental info on board:

Sketch of radiative and turbulent fluxes and precipitation (exclude subsurface)



all energy fluxes in units of W m^{-2} positive towards the glacier surface

Simplified surface energy balance to get melt energy:
$Q_M = Q_S + Q_L + Q_H + Q_E + Q_P$

Reminders of useful things:
Net $Q_S = (SW_{IN} – SW_{OUT})$
Albedo = SW_{OUT} / SW_{IN}

Melt rate = Q_M / (density * Lf)
NB. Using density of water gives you the melt rate in water equivalent depth

Lf = 334 kJ kg^{-1}
Lv = 2500 kJ kg^{-1}

Check that students know what all the terms are – add the definitions as they answer them.

Questions:

1. Getting signs (+/-) right is deceptively hard, but very important. Where is energy coming and going?
   a. What does a positive Q_M mean?
   b. If the vapor pressure gradient is + (increasing with height), what will happen?
   c. Is Q_E + or – when sublimation occurs?
   d. Can Q_R (net radiative flux) ever be negative? If so, what is physically happening?
2. The glacier ice surface is at the melting point. The following variables are measured at a weather station on the glacier ice (daily means):
   global radiation = 200 W m^{-2},
   incoming longwave radiation = 280 W m^{-2},
   albedo = 0.4,
   sensible heat flux = 30 W m^{-2}
   latent heat flux = 20 W m^{-2}
   a. How much energy is available for melting?
   b. How much ice melt (surface lowering) occurs that day? (cm)
   c. What is the ablation rate under these conditions (mm w.e. day^{-1})