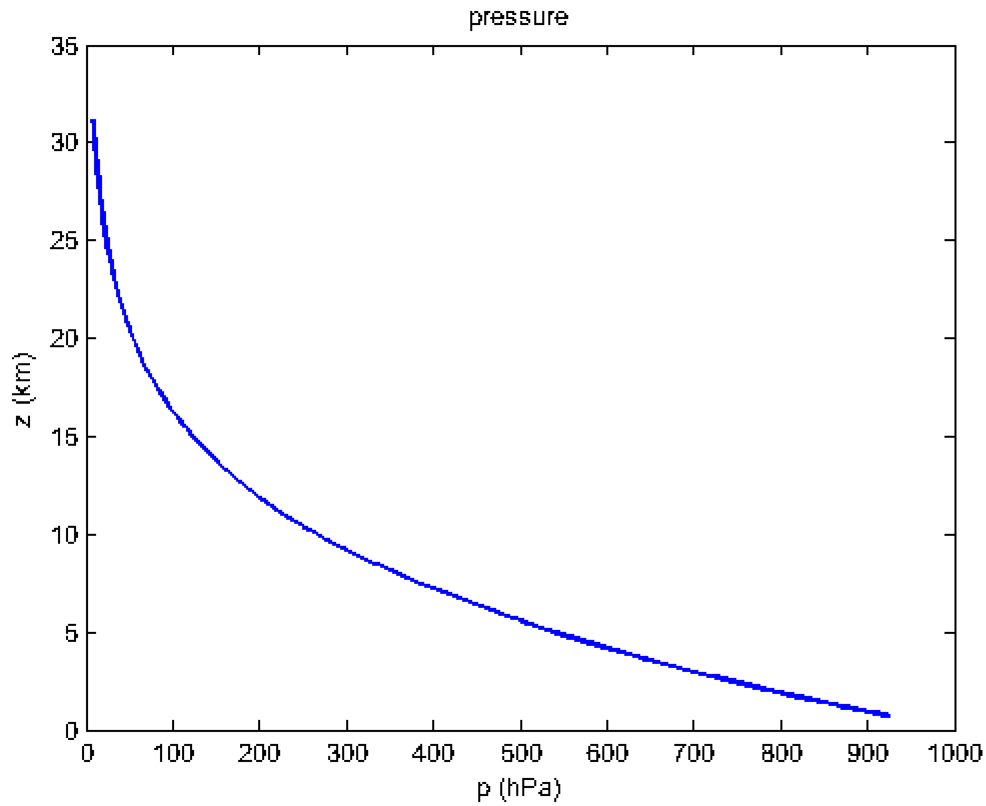
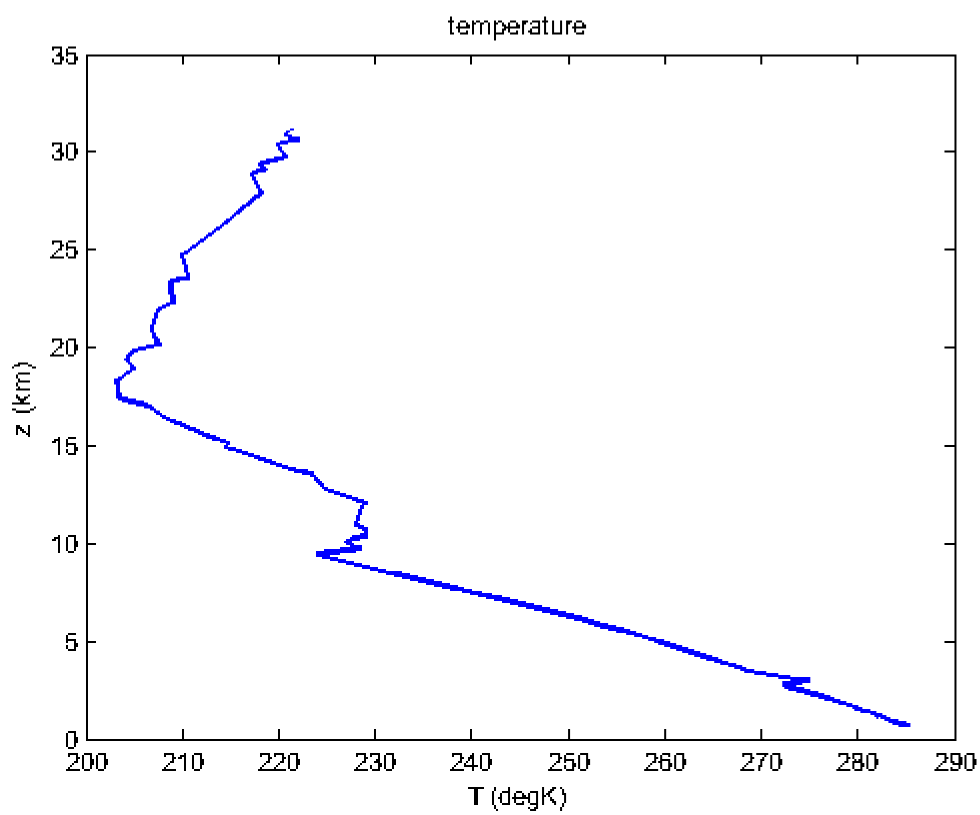
MAE 578 Spring 2019 HW2 Solution

Prob 1

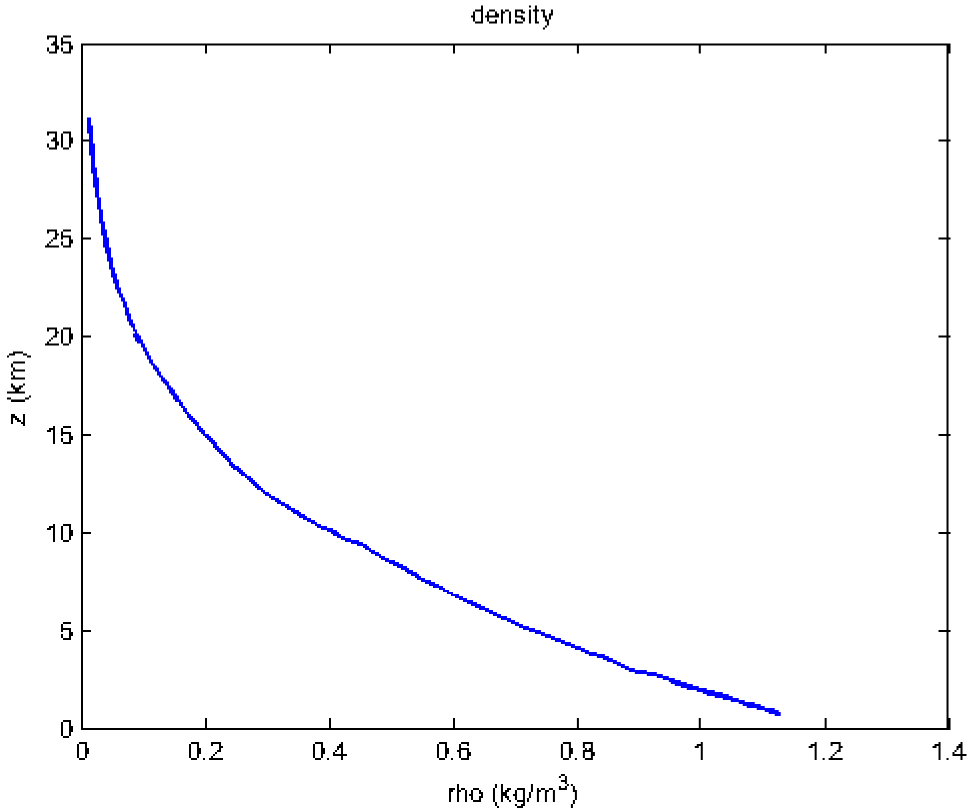
Pressure



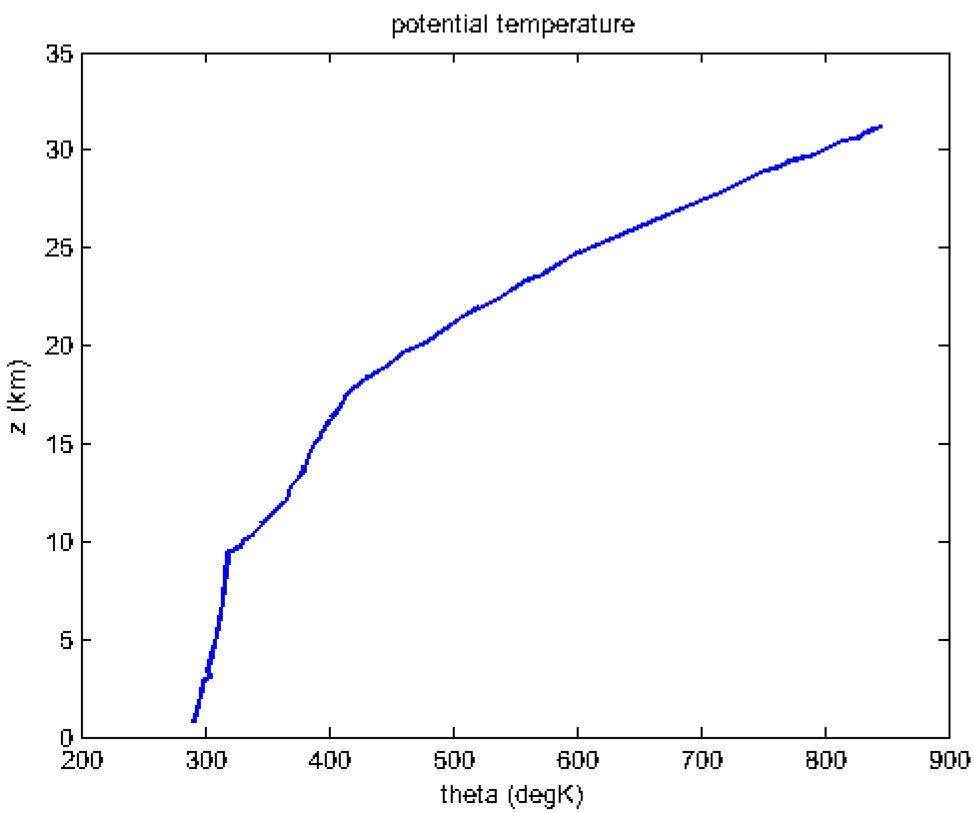
Temperature



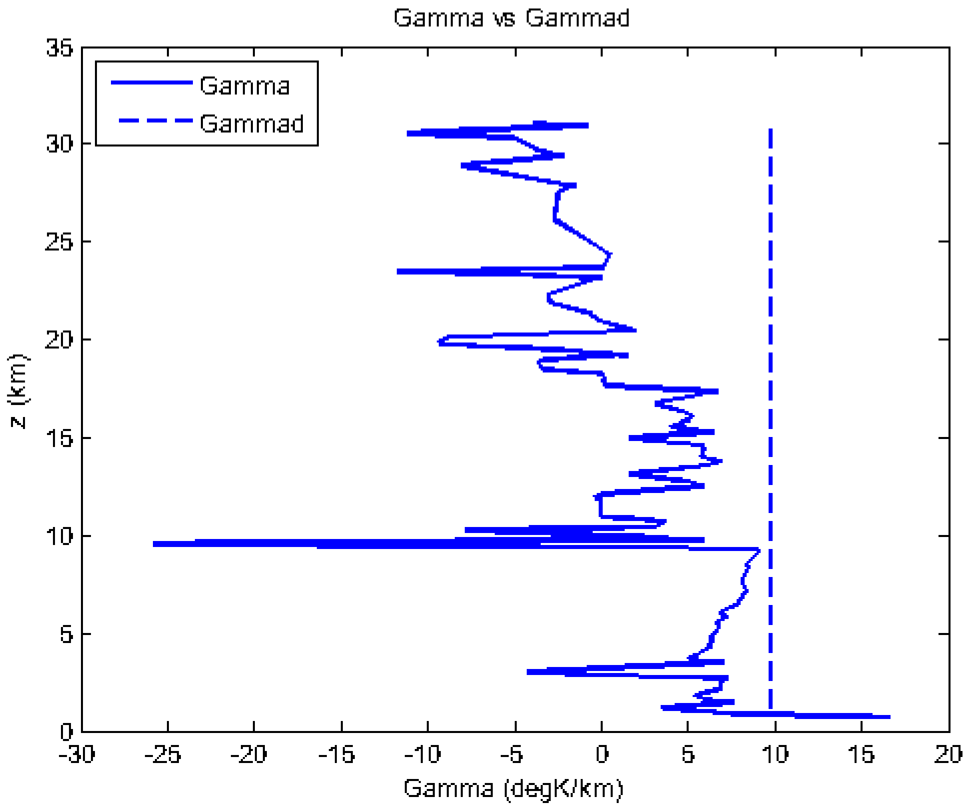
Density



Potential temperature
(Note: This calculation incidentally used p = 1000 mb, instead of 924 mb, as the reference pressure. Both versions of θ are legitimate and they differ only by a constant factor that does not affect the conclusion on static stability.)



Lapse rate: Γ vs. Γ_d
(The detail of this plot is somewhat sensitive to the numerical schemes used for vertical interpolation and differentiation.)



The tropopause is located at around z = 18.3 km

By the dry stability criterion, the atmospheric profile is statically stable at all levels except an isolated spot very near the surface.
(The observational data was from a sounding at Tucson, Arizona, taken at 12UTC in January 31, 2015. The atmosphere is actually more unstable at that time if the effect of moisture is taken into account. This is beyond the scope of this exercise.)

Prob 2

The lapse rate is – dT/dz = g/R, which is much greater than the dry adiabatic lapse rate, g/C_p. The segment of the atmosphere is statically unstable.

Prob 3

We will discuss the solution in class. For Part (c), the magnitude of vertical velocity is around 0.0006 m/s if we assume that vertical velocity is independent of height. The observed vertical velocity (over Sahara) at 500 mb level is stronger, in the range of 0.001-0.003 m/s depending on which location we pick. The discrepancy can be explained by the fact that, in reality, vertical velocity is not vertically uniform but tend to reach a maximum (in magnitude) in the middle of troposphere. Thus, w at 500 mb level is generally greater (in magnitude) than the vertically averaged w.