MAE 598 Fall 2012 Homework #2 The difficulty level of this exercise is "**E**"

1. In the vicinity of the City of Tempe, marked by a circle in Fig. 1, a rectangular grid of meteorological stations was set up to collect observations of temperature, velocity, etc. The spacing of the stations is 50 km in both x- and y-direction. At 9 PM of a certain day, the observation of the flow at the vertical level of z = 3 km indicates that (see illustration in Fig. 1) (i) The horizonal velocity is uniform in space and points to the northeast with a speed of 5 m/s. The wind vectors (red arrows) form a 45° angle with the x-axis, and (ii) The temperature contours (bold gray lines) are straight and equally spaced lines that form an angle, θ, with the x-axis where tan θ = 0.5. The temperature at Tempe is 10°C. Moreover, from the observations of temperature at other vertical levels, it has been determined that (iii) The vertical lapse rate over the area of interest is $\Gamma \equiv -\partial T/\partial z$ = 8 °C/km at the z = 3km level. (The atmosphere is statically stable.)

From the observations of the horizontal velocity at other vertical levels, your colleague has performed a vertical integration of the horizontal wind divergence to determine that (iv) The vertical velocity at z = 3km is approximately −5 cm/s (a subsidence) over the area of our interest. Lastly, your colleague has also performed a radiative transfer calculation to estimate that (v) The radiative <u>cooling</u> rate ($\dot{Q}/c_p$ is negative) of the atmosphere at z = 3 km is approximately 2°C/hour over the area of our interest. Using the information from (i)-(v) and ignore the effect of moisture, try to make a prediction of the temperature at z = 3km for Tempe at 10 PM (i.e., an hour later) using the standard temperature equation,

$$\frac{\partial T}{\partial t} = -u\frac{\partial T}{\partial x} - v\frac{\partial T}{\partial y} + (\Gamma - \Gamma_d)w + \dot{Q}/c_p \quad , \qquad \text{Eq. (1)}$$

where $\Gamma \equiv -\partial T/\partial z$ is the vertical lapse rate of the environmental temperature and $\Gamma_d \equiv g/c_p$ is the dry adiabatic lapse rate.

Note: In reality, most weather observation and forecast systems use pressure (instead of height) as the coordinate. For the purpose of this exercise this is not critical. We assume that the vertical level shown in Fig. 1 is a constant-z level and the "w" in Eq. (1) is the vertical velocity in z-coordinate. The (u,v) given in the problem is the horizontal velocity at this constant-z level.

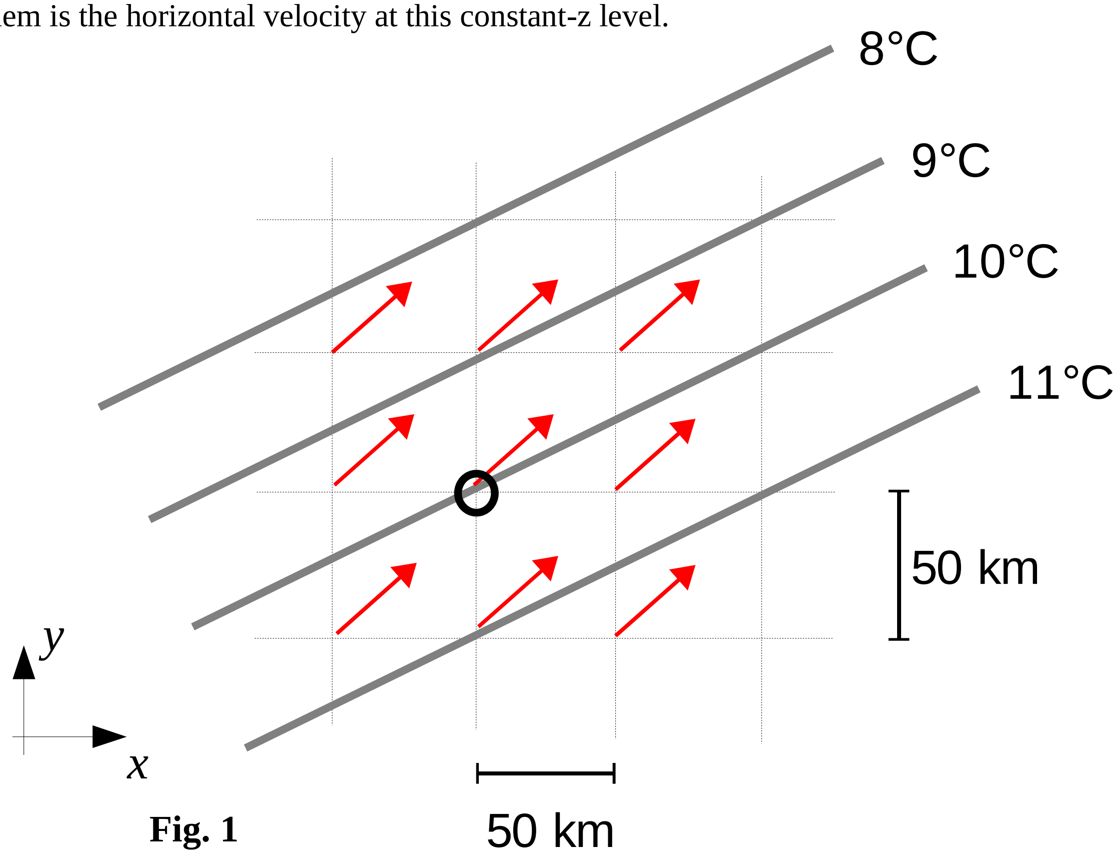

Fig. 1