Atm 409–509 **Problem Set #2** **Fall 2016**

NOTE: Problem 2a and b is optional for undergraduate students

1. During the 6-hour period ending 0300 UTC 14 March 1993 the Portland (PWM), Maine, area received upwards of 40 cm of snow from the "Blizzard of '93." Compute the mid-tropospheric vertical motion necessary to produce 40 cm 6-hour snowfall amounts. Express your answer in units of hPa s^{-1} and cm s^{-1} at 600-hPa.

Assume:

a) Density of snow is 1/10 density of liquid water.

b) Moistest possible sounding, i.e., T = 0°C from the surface (1000 hPa) to 700 hPa, then dropping to -20°C at 400 hPa, saturated throughout.

c) A parabolic profile of vertical velocity as follows:

$$\omega(p) = [\hat{\omega}(1000 - p)(p - 200)]/(400)^2 \qquad \text{(p in hPa)}$$

Here $\hat{\omega}$ is the maximum value of ω (ascent) at 600 hPa. This equation yields the following values of ω as a function of p (hPa):

p (hPa)	$\omega/\hat{\omega}$
450	0.86
550	0.98
650	0.98
750	0.86
850	0.61
950	0.23

d) Condensation and precipitation rates are equal, and neglect condensation above 400 hPa.

e) An adiabatic chart (e.g., a Skew-T log-p diagram) is obviously helpful.
See: http://www.weathergraphics.com/reference/wpc-916.jpg

2a. Compute the horizontal temperature advection at 850 hPa in the vicinity of PWM at 0000 UTC 14 March 1993. Use any suitable means for the calculation (e.g., a hand calculation made from the NARR temperature, vector wind, and geopotential height analyses shown in Figs. 1–3 or a direct calculation made from the NARR gridded datasets). Assume a 50 km length scale for horizontal gradients in this question. Justify all additional assumptions.

NARR gridded datasets:
https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/north-american-regional-reanalysis-narr

NARR (NOAA/ESRL/PSD):http://www.esrl.noaa.gov/psd/cgi-bin/data/narr/plothour.pl

2b. Compute the 850 hPa local temperature tendency at PWM at 0000 UTC 14 March 1993. Use the result of problem 1a to compute the adiabatic heating and cooling term (use the same 50 km length scale). Make an estimate of the diabatic heating term by any suitable means (note: you will have to play meteorologist in order to perform this calculation).

3a. The Miami, Florida, International Airport (MIA) measured 7.32 inches (18.6 cm) of rain in the 6-hour period ending 0000 UTC 4 October 2000. Compute the mid-tropospheric vertical motion necessary to produce this rainfall total using the same methodology as in problem #1. Express your answer in the same units.

The MIA surface observation at 0000 UTC 4 October 2000 was as follows:

KMIA 032356Z 26010KT 4SM +RA BR FEW008 BKN024 OVC046 23/23 A2991 RMK AO2 SLP129 P0054 60732 T02330228 10256 20228 53005=

Assume that the MIA sounding for 0000 UTC 4 October 2000 (Fig. 4) is moist adiabatic from the surface to 400 hPa. As a test of this assumption, note that lifting a parcel moist adiabatically from 1012.9 hPa with a temperature and dew point temperature of 23°C produces a 500-hPa temperature close to the observed -4°C sounding value at 500 hPa.

3b. Discuss your results synoptically and compare and contrast the tropical rainstorm at MIA with the midlatitude snowstorm event at PWM.

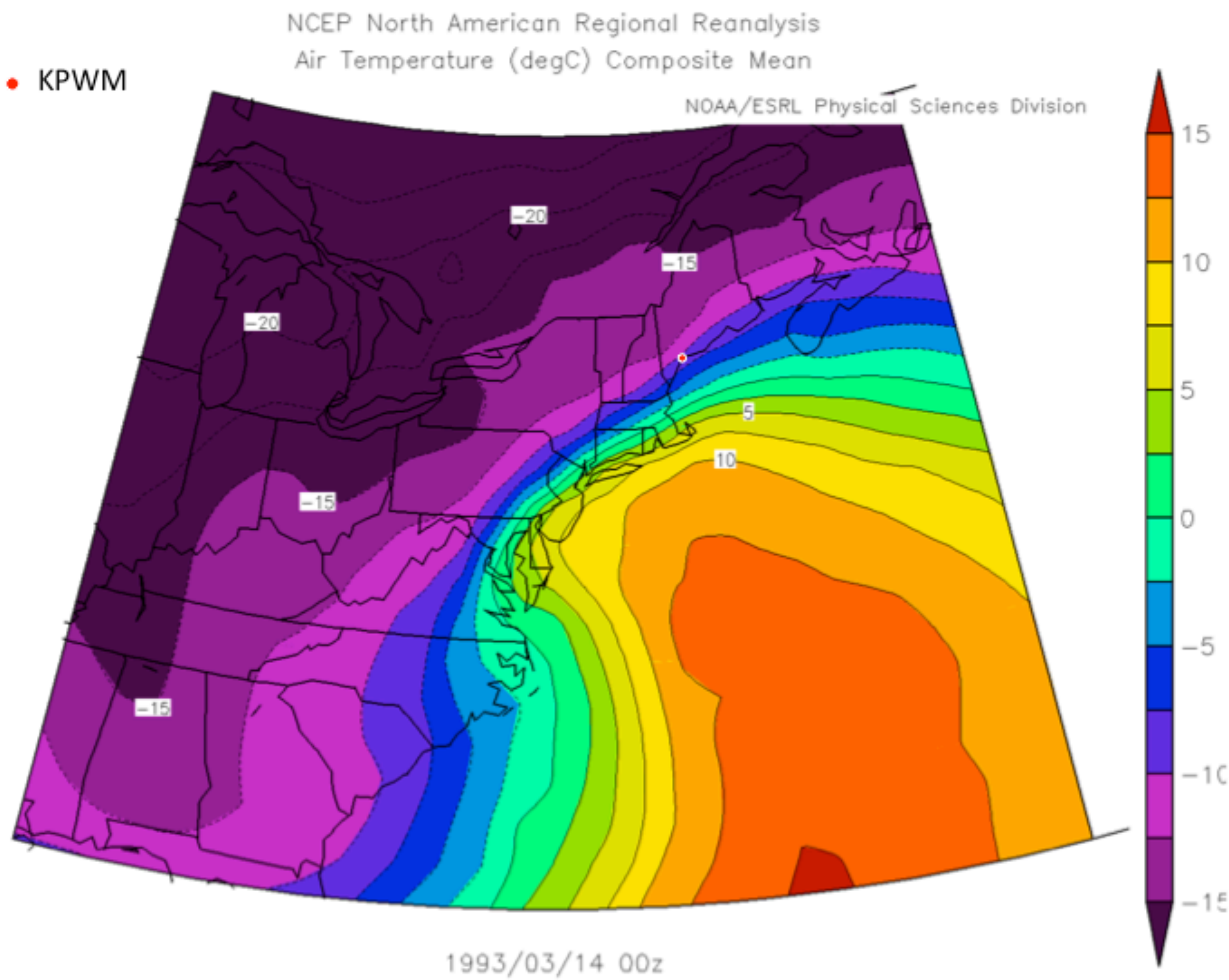

Figure 1. NARR Analysis for 850-hPa temperature (shaded, °C) over the northeastern US on 0000 UTC 14 March 1993

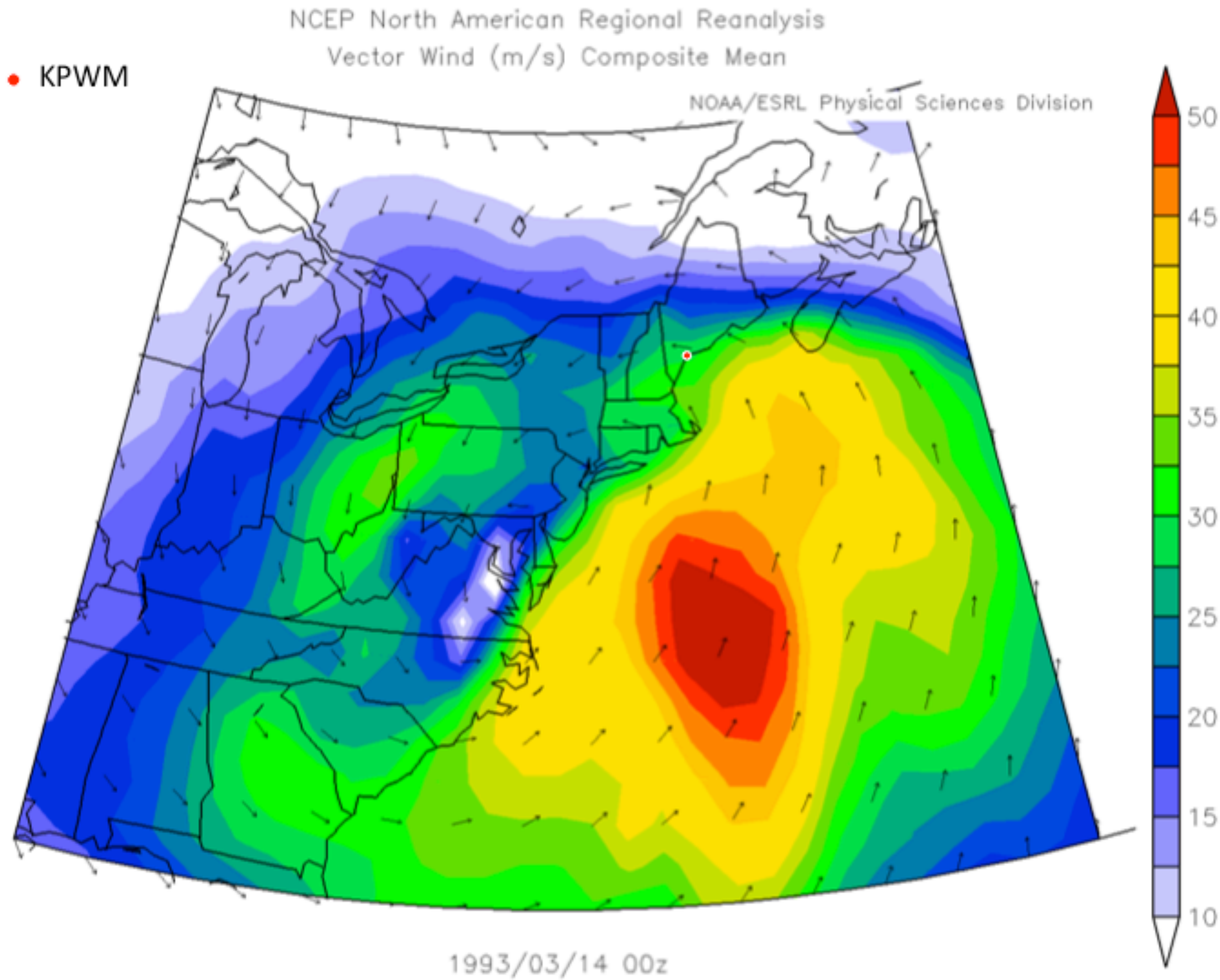

Figure 2. NARR Analysis for 850-hPa wind speed (shaded, m s^{-1}), and direction (vectors) for 0000 UTC 14 March 1993

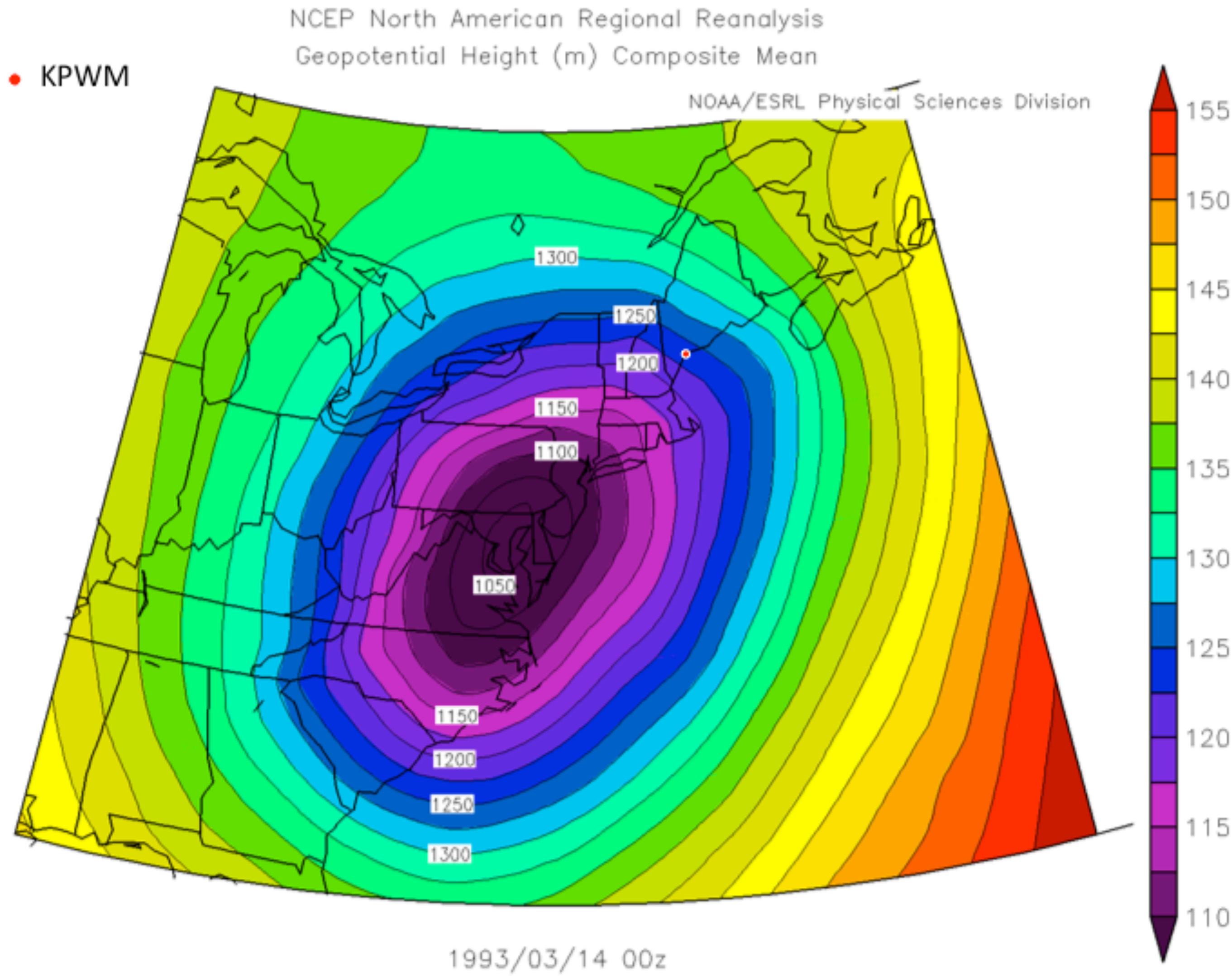

Figure 3. NARR Analysis 850-hPa geopotential height (shaded, gpm) for 0000 UTC 14 March 1993.

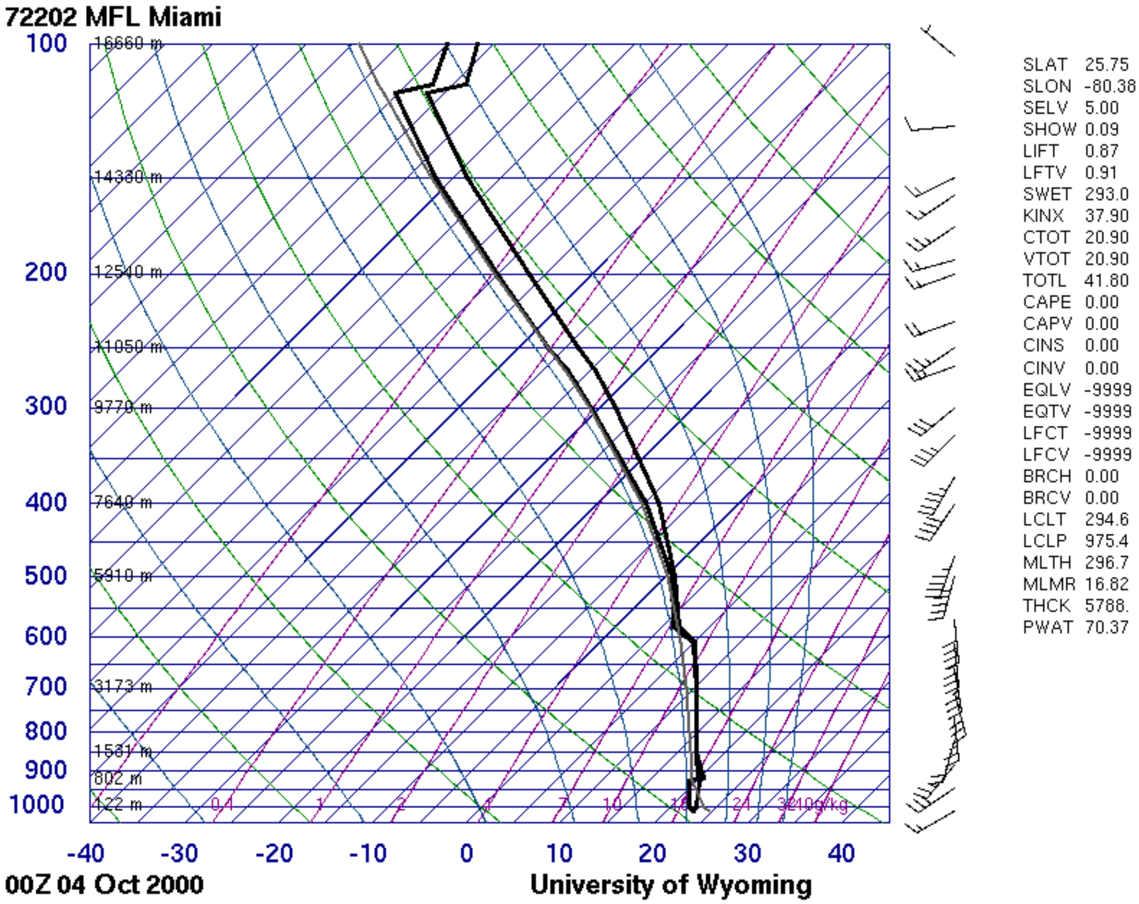

Figure 4. Skew-T Log-P diagram for Miami, FL on 0000 UTC 4 October 2000