1. Watch this YouTube video: [http://youtu.be/5ZmxbgW2W4Q](http://youtu.be/5ZmxbgW2W4Q) (Courtesy of AOS and SSEC at the University of Wisconsin-Madison)

This video shows a westward looking time-lapse of a thunderstorm approaching Madison, WI. We’re going to focus on the first 10 second of the video, a period when there is noticeable vertical wind shear, as represented by the cloud motion varying with height. The corresponding METAR observation, taken during the earliest part of passage of the thunderstorm,

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indicates that the lowest clouds are at the 4300 ft (e.g., 1.3 km or ~850 hPa) level and the highest clouds are at the 11000 ft (e.g., 3.3 km or ~650 hPa) level.

a) Assuming the motion of these clouds can be accounted for by the geostrophic component of the wind, describe the type of temperature advection that coincided with this video. Make use of a diagram to explain your answer.

b) Assume the magnitude of the wind is 10 m s⁻¹ at both the upper and lower cloud levels, find the magnitude and direction of the $T_v$ gradient associated with this frontal passage using $P = 750$ hPa.

2. Consider Figure 1, which shows 1000-500 hPa thickness contours (dashed lines) along with isopleths of some variable $Y$ (solid lines). $Y$ has the same values at 500 hPa as it does at 1000 hPa.

At which level, 1000 or 500 hPa, is the geostrophic advection of $Y$ at station A larger? Explain your answer and reference Figure 1 below.

*(Hint: your answer can be proved with the basic physical definition of thermal wind.)*

*Figure 1: The 1000-500 hPa thickness contours (dashed lines) and isopleths of variable $Y$ (solid lines). $Y$ has the same values at 500 hPa as it does at 1000 hPa.*