ATSC 5160 Homework 6 4% due Friday 14 April 2006

1. Show that isentropic potential vorticity P is proportional to $F^2N^2 - S^4$, where the symbols are as defined in the class notes on symmetric instability (hint: transform θ coordinates to height coordinates)(1%)

2. Symmetric instability (SI) and baroclinic instability (BI) are both favored by a large horizontal temperature gradient (i.e. steeply sloping isentropes, $\left|\nabla_p \theta\right|$ large) and thus a strong jet stream aloft (thermal wind). While this is a sufficient condition for BI, it is not for SI. What is the condition for SI? Show that SI is indeed more likely when $\left|\nabla_p \theta\right|$ is large.

3. Why is it that potential symmetric instability (PSI) is more likely to be released above a frontal surface, thus giving rise to frontal rainbands, and first described by Hobbs et al?

4. Imagine 10 m/s flow impinging on a 1 km high mountain ridge. How large does the temperature lapse rate in the lower troposphere need to be for the airstream not to be blocked by this (infinitely long) barrier?

5. Imagine low-Froude-number flow (Fr<1) impinging on an isolated mountain, e.g. the trade winds approaching the big island of Hawaii. Show the sea level pressure and low-level wind patterns in the vicinity of the mountain. Also show some isotachs indicating where the flow is faster or slower than the background flow of 10 m/s. Finally, sketch a cross section across the mountain (upstream to downstream), showing the depth of the marine BL and the location of the surface L and H pressure centers.

6. Imagine a deep marine boundary-layer (MBL) crossing an elongated island. The MBL depth is twice the height of island’s ridge. What upstream wind speed is needed in order to get a downslope windstorm (i.e. supercritical flow on the lee slope of the ridge, with a downstream hydraulic jump). For simplicity, assume that the fluid is water. Hint: assume both energy and mass conservation, and evaluate energy and mass at a point upstream, and at the island’s crest.