

ATS 602 – Homework 1

due Thursday, February 2, before class

1. Hoskins et al. PV paper.

- (a) Read through the first two sections of Hoskins et al. (1985) and write down questions for class discussion (preferably you already have some questions for Tue 1/24).
- (b) Recreate Figures 2-7 of the paper using modern reanalysis data (see link on website, Louis can help), similar to my example on the lecture slides from the 1st class. You may choose a different map projection than used in the paper. Feel free to produce animations where appropriate (e.g. Fig. 3).
- (c) Consider Rossby's PV (Eq. 8). Show that the layer thickness $\Delta = -\delta p/g$ is "the mass per horizontally projected area".
- (d) Provide an approximation of Rossby's PV for small Rossby number and interpret.
- (e) Derive a relation between the 'isentropic vorticity' (Eq. 9) and relative vorticity in pressure coordinates. Approximate the horizontal potential temperature gradients that appear by using the thermal wind relation and finally show that:

$$\zeta_{\theta} \approx \zeta_p - f Ri^{-1},$$

where $Ri \equiv N^2/S^2$ is the so-called Richardson number, with stratification parameter $N^2 \equiv g\theta^{-1}\partial_z\theta$ and shear parameter $S^2 \equiv (\partial_z u)^2 + (\partial_z v)^2$. Under what conditions is $\zeta_{\theta} \approx \zeta_p$?