Reply to J. Egger

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Egger would appear to be correct in his assertion that Smith's (1969) result $dp_r/dt = 0$, is wrong despite its appealing simplicity.

Given that Smith's result is not correct, it remains to be pointed out that this does not alter the results obtained in Boer (1975). Recalling equations 5 and 6, one may write

$$\frac{d}{dt} C_p NT = \omega\alpha + NQ - C_p T \left(\frac{p_r}{p}\right)^{\varkappa} \frac{\varkappa}{p_r} \frac{dp_r}{dt}$$

which becomes upon integrating over the mass of the atmosphere

$$\frac{\partial}{\partial t} \int C_p NT\, dm = \int NQ\, dm + \int \omega\alpha\, dm - \int C_p T \left(\frac{p_r}{p}\right)^{\varkappa} \frac{\varkappa}{p_r} \frac{dp_r}{dt}\, dm$$

or

$$\frac{\partial A}{\partial t} = G - C - R$$

where A, G, C are the usual expressions for the available potential energy and the rates of generation and conversion thereof.

The remainder term R, depends on dp_r/dt and can be shown to be zero. Consider

$$R = \int C_p T \left(\frac{p_r}{p}\right)^{\varkappa} \frac{\varkappa}{p_r} \frac{dp_r}{dt}\, dm$$

$$= \iint C_p \theta \left(\frac{p_r}{p_s}\right)^{\varkappa} \frac{\varkappa}{p_r} \frac{dp_r}{dt} \frac{\partial p}{\partial \theta} \frac{d\theta}{g}\, d\sigma$$

$$= \int C_p \theta \left(\frac{p_r}{p_s}\right)^{\varkappa} \frac{\varkappa}{p_r} \overline{\frac{dp_r}{dt} \frac{\partial p}{\partial \theta}}\, \sigma_e \frac{d\theta}{g}$$

where σ_e is the area of the earth and the overbar indicates the average over a θ surface, i.e.

$$p_r = \bar{p} = \frac{1}{\sigma_e} \int p(x, y, \theta, t)\, d\sigma$$

Egger gives

$$\frac{dp_r}{dt} = -\dot{\theta} \overline{\frac{\partial p}{\partial \theta}} + \dot{\theta} \frac{\partial p_r}{\partial \theta}$$

whence it follows that

$$\overline{\frac{dp_r}{dt} \frac{\partial p}{\partial \theta}} = -\dot{\theta} \overline{\frac{\partial p}{\partial \theta}} \frac{\partial p_r}{\partial \theta} + \dot{\theta} \overline{\frac{\partial p}{\partial \theta}} \frac{\partial p_r}{\partial \theta} = 0$$

and that $R = 0$.

The results given in Boer (1975) then follow as before. It should perhaps be noted that Smith's (1969) equations for the available potential energy of a limited region should apparently include a term analogous to R and that, for the limited region, it is not obvious that such a term would be zero.