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On some aspects of diabatic heating and vertical velocity

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Summary

Neglecting the effects of friction from the complete vorticity and thermodynamic equation in the derived omega equation, we have three different terms for forcing given on the right hand side of the equation (1).

$$\nabla^2\omega + \frac{f^2}{S}\frac{\partial^2\omega}{\partial p^2} = \frac{1}{S}\left[\frac{\partial}{\partial p}J(\phi,\eta) + \frac{1}{f}\nabla^2 \cdot J\left(\phi, -\frac{\partial\phi}{\partial p}\right)\right] - \frac{f}{S}\frac{\partial}{\partial p}\left(\frac{\partial\omega}{\partial y}\frac{\partial u}{\partial p} - \frac{\partial\omega}{\partial x}\frac{\partial v}{\partial p}\right) - \frac{f}{S}\frac{\partial}{p}\left(\xi\frac{\partial\omega}{\partial p} - \omega\frac{\partial\xi}{\partial p}\right) - \frac{R.\nabla^2 q}{c_p.Sp.} \quad (1)$$

The magnitude of the second and third terms of the above equation as per our calculation for the Indian region at 99 grid points at the intervals of 2° longitude/latitude are of the order of 10^{-10} to 10^{-11} mb^{-1} sec^{-2} at the 800, 600 and 400 mb surfaces and that of the omega is 10^{-3} to 10^{-5} mb/sec. Thus we can safely neglect the small terms and are left with the simple form of the omega equation,

$$i.e., \nabla^2\omega + \frac{f^2}{S}\frac{\partial^2\omega}{\partial p^2} = \frac{1}{S}\left[\frac{\partial}{p}J(\phi,\eta) + \frac{1}{f}\nabla^2 J\left(\phi, -\frac{\partial\phi}{\partial p}\right)\right] \quad (2)$$

and making use of the thermodynamic equation we find the vertical velocity due to diabatic heating as

$$\frac{\partial^2\omega_2}{\partial p^2} = -\frac{g}{f^2}\nabla^2\gamma(x,y,p) \quad (3)$$

$$q = [\gamma(x,y,p) - k\omega_2]\frac{c_p.g.p}{R} \quad (4)$$

From these relations we have computed vertical velocity due to baroclinic effects, due to diabatic heating; diabatic heating for the Indian region at 800, 600, 400 mb surfaces using the boundary conditions ω_1, ω_2 and q to be zero at 1000 and 200 mb surfaces.

The magnitude of vertical velocity due to baroclinic effects varies between 10^{-3} to 10^{-5} mb sec^{-1} at 800, 600, 400 mb surfaces and that due to diabatic heating 10^{-5} to 10^{-8} mb/sec at 800 mb and 10^{-3} to 10^{-5} mb/sec at 600 and 400 mb surfaces. The magnitude of diabatic heating ranges between 0.5 to 4.0 cal. gm^{-1} 12 hr^{-1}

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