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Geoscientific Model Development Discussions

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Interactive comment on "Quasi-hydrostatic equations for climate models and the study on linear instability" *by* Robert Nigmatulin and Xiulin Xu

Xiulin Xu

xiulin.xu@icloud.com

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Dear Ilias Sibgatullin,

Thank you very much for your comments. In the following sentence:

"But the 'simplification' is made in such a way that additional (uncompensated) vertical velocity appears and conservation of the full energy is violated."

Can you explicitly explain how the conservation of full energy is violated in the equations?

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Discussion paper

To answer

"The ’simplification’ made by the First Author of the Paper is the neglect of the horizontal advection of pressure in $\frac{\mathrm{d}p}{\mathrm{d}t}$ upon scale analyses of one component of the horizontal divergence of mass flux.",

I copy the text (slightly different from the current version of manuscript because of written errors) from the paper to show how the horizontal pressure divergence terms are estimated:

To estimate the fourth and fifth terms on the right side of (2.13), the horizontal gradients of pressure is estimated from (2.6) and horizontal momentum equations (1.2), (1.3)

$$\frac{\partial p}{\partial x}, \frac{\partial p}{\partial y} = \rho O\left(\frac{V_{\text{hor}}^2}{L_{\text{hor}}} + \frac{V_{\text{hor}}^2}{L_{\text{cor}}}\right), \quad (L_{\text{cor}} = V_{\text{hor}}\tau_{\text{cor}}). \tag{1}$$

Then, taking into account (2.15), we get

$$\frac{v_x(\partial p/\partial x) + v_y(\partial p/\partial y)}{g\dot{M}} = \frac{\{v_x(\partial p/\partial x) + v_y(\partial p/\partial y)\}/\gamma p}{g\dot{M}/\gamma p} \sim$$

$$\sim \frac{V_{\text{hor}}\rho}{\gamma p} O\left(\frac{V_{\text{hor}}^2}{L_{\text{hor}}} + \frac{V_{\text{hor}}^2}{L_{\text{cor}}}\right) / O\left(\frac{V_{\text{hor}}}{L_{\text{hor}}}\right) = O\left(\frac{V_{\text{hor}}^2}{C^2} + \frac{L_{\text{hor}}V_{\text{hor}}^2}{L_{\text{cor}}C^2}\right) = \left(1 + \frac{L_{\text{hor}}}{L_{\text{cor}}}\right) O\left(\text{Ma}^2\right)$$

Therefore, the horizontal pressure divergence terms were estimated in the frame of scales we are interested in. We can drop these terms in the equation for vertical velocity (2.13) and get the asymptotically exact result for $\epsilon \to 0$ only when we use the scales (2.1).

Thank you again for your interest in our work!

Sincerely,

Xiulin Xu

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