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Meteorology 443

Mid-Term Test
22 February 2002

Closed-book test: 50 minutes

Point

I. Answer the following questions (answers should be brief):

2 a. What is the difference between coriolis force and centrifugal force?

2 b. What is the difference between gravity and gravitational force?

2 c. Is there frictional force if velocity is uniform? Explain your answer.

2 d. Which reference frame is more convenient to describe atmospheric motion with station observations? Explain your answer.

3 e. Two geopotential height contours with a difference of 20 meters is separated by a distance of 200 km. What is the magnitude of pressure gradient force generated by this synoptic condition?

4 f. The temperature difference between Des Moines and Minneapolis is 10°C. A distance of 400 km and a uniform northerly wind of 10 ms^{-1} exists between these two cities. How much temperature decrease at Des Moines may be caused by the cold air advection between these two cities?

II. Synoptician often uses thickness (Z_T) to measure the layer-mean temperature (<T>):

$$Z_T = \frac{R}{g} \langle T \rangle \ln (P_1/P_2) \qquad (1)$$

2 a. What is the most basic assumption of the atmospheric vortical condition to obtain Eq.(1)?

4 b. Use Eq.(1) to explain why pressure decreased more rapidly with height in a cold layer than in a warm layer.

III. The continuity equation is written as $\frac{1}{\rho}\frac{d}{dt}\rho + \nabla \bar{u} = o$

2 a. Why is synoptic-scale motion quasi-horizontal?

3 b. What are conditions to make synoptic-scale motion horizontally nondivergent?

IV. The momentum equation derived from Newton's second law of motion is

$$\frac{d\vec{u}}{dt} = -\frac{1}{\rho}\Delta p + \vec{g} + \vec{F}_r. \qquad (2)$$

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whi ch is transformed to

$$\frac{d\vec{u}}{dt} = -2\vec{\Omega} \times \vec{u} - \frac{1}{\rho}\nabla p + \vec{g} + \vec{F}_r, \qquad (3)$$

and

$$\frac{du}{dt} - 2\Omega\, v\sin\Phi + 2\Omega\, w\cos\Phi + \frac{uw}{a} - \frac{uv}{a}\tan\Phi = -\frac{1}{\rho}\frac{\partial p}{\partial x} + Fx, \qquad (4)$$

$$\frac{dv}{dt} + 2\Omega\, u\sin\Phi + \frac{vw}{a} + \frac{u^2}{a}\tan\Phi = -\frac{1}{\rho}\frac{\partial p}{\partial x} + Fy. \qquad (5)$$

2 a. What are two fundamental forces to drive the atmospheric motion in Eq.(2)?

3 b. Can we use directly Newton's second law of motion to depict the atmospheric motion? Explain your answer.

2 c. Why should we use Eqs. (4) and (5) to portray the atmospheric motion?

V. Performing the scale analysis of synoptic motion, one can simplify Eqs. (4) and (5) to the following forms by maintaining terms with magnitude order of 10^{-4} ms-^{2}:

$$\frac{du}{dt} - fv = -\frac{1}{\rho}\frac{\partial p}{\partial x}, \qquad (6)$$

$$\frac{dv}{dt} + fu = -\frac{1}{\rho}\frac{\partial p}{\partial y}. \qquad (7)$$

3 a. Sketch a schematic diagram to illustrate the relationship between geostrophic wind and isobars.

4 b. What is the difficulty to predict the synoptic-scale motion with Eqs. (6) and (7)?