Department of Atmospheric Sciences
National Central University
Advanced Applied Mathematics
Homework VI
2021/11/26-2022/01/14

This homework is about the application of variational analysis in thermodynamic retrieval. The following is the momentum equations, and Fig. 1 depicts the horizontal wind field at Z=6. Suppose we have already used the radar-derived 3D wind fields to compute the F、G and H (shown in Fig. 2 for Z=6) on the right-hand-side of the momentum equations, your missions are:

(1) Get the files containing F、G、H and θ_{v0} , θ_0 from your TA.

(2) Plot the fields of F、G and H, and make sure your input data are correct.

(3) Use variational method introduced in class to retrieve the pressure and temperature perturbation fields (π', θ_c') at each layer. Please show the results at Z=2, 4, 6, 8.

Note that using the method we discussed in class you can only recover the perturbations' deviations from their horizontal average. **In this homework you can practice how to implement the Neumann boundary conditions.** The deadline of this homework is 2022/1/14, which is the last day of this semester. You will have enough time to finish this homework and prepare your final oral presentation.

The number of grids is 31 x 21 x11, and the grid size is DX =1km, DY=1km, DZ=0.25km.

The definitions of F、G and H are described as follow .

$$\pi = C_p \left(\frac{P}{P_0}\right)^{\frac{R}{C_p}}$$

$$\frac{1}{\theta_{v0}}\left[\frac{\partial u}{\partial t} + \boldsymbol{V}\cdot\nabla \mathrm{u} - fv + turb(u)\right] = -\frac{\partial \pi'}{\partial x} \equiv -F$$

$$\frac{1}{\theta_{v0}}\left[\frac{\partial v}{\partial t} + \boldsymbol{V}\cdot\nabla \mathrm{v} + fu + turb(v)\right] = -\frac{\partial \pi'}{\partial y} \equiv -G$$

$$\frac{1}{\theta_{v0}}\left[\frac{\partial w}{\partial t} + \boldsymbol{V}\cdot\nabla \mathrm{w} + turb(u) + g(q_r + q_s)\right]$$

$$= -\frac{\partial \pi'}{\partial z} + g\frac{\theta_c'}{\theta_{v0}\theta_0} \equiv -H$$

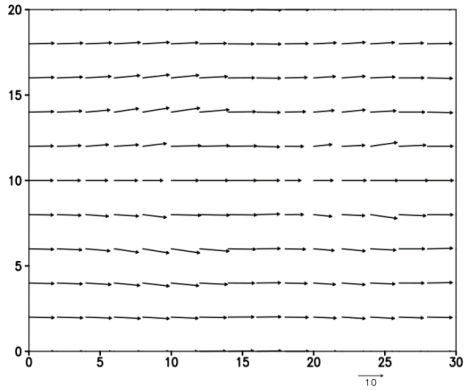
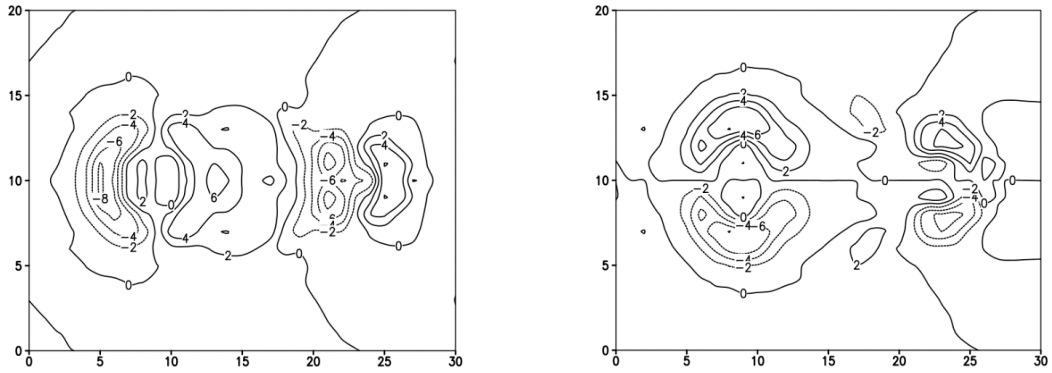


Figure 1. Horizontal wind field(Z=6)

(a) (b)



(c)

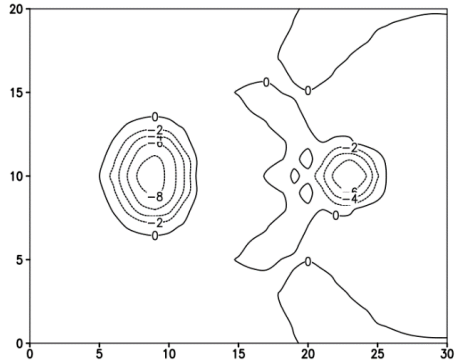


Figure 2. Fields of (a)F ; (b)G, but multiplied by 10^5; and (c) H, but multiplied by 10^4, at Z=6.