HW2

Q1

(a) Discuss what causes the instability of *q* from timescales of (1) shorter than the intrinsic timescales of Rossby wave (i.e., < 14 days) and (2) longer than the wave intrinsic timescales (i.e., ≥ 14 days). Which term can (cannot) be omitted in the first (second) case? Why?

Shorter than wave intrinsic timescaels: Existence of wind shear and PV gradient.

Longer than wave intrinsic: large scale forcing (e.g. from MJO) that leads to the divergence at upper level.

(b) When an atmospheric blocking happens, the upper and lower troposphere tends to be more barotropic (i.e., high and low pressure centers over different vertical layers are spatially collocated). From the perspective of baroclinic instability, discuss why the atmospheric blocking has a much longer life cycle than a typical extratropical front?

上層高壓左側為正渦度平流，使得位渦增加，使高底層間的厚度減少，$\omega < 0$，有助於底層低壓增強。下層低壓左側所產生的冷平流能減少上層的等位面，進而使得渦度增加，加強上層的高壓。

Q2

(a) Using Dedalus (on google colab) to simulate Rayleigh-Benard convection. Testing low Rayleigh number (~ 101) and high Rayleigh number case (~ 108). Run the model long enough to have a dynamical equilibrium state. Plot the results and discuss the difference

1. Rayleigh number = 1e8:

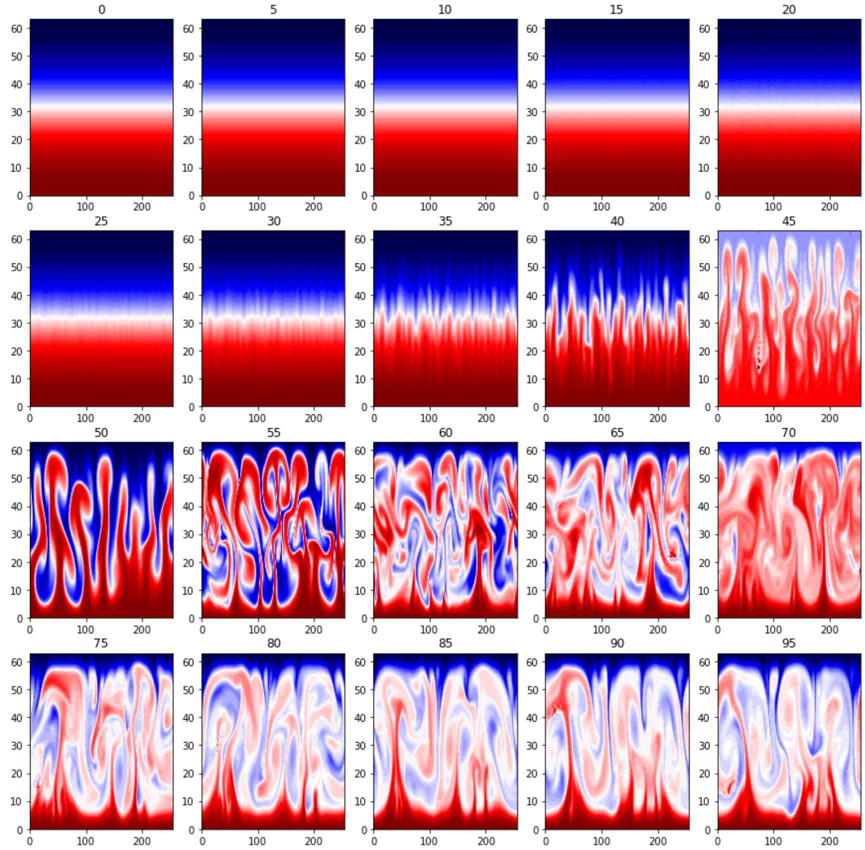

Fig. 1: Rayleigh-Benard convection with Rayleigh number = 1e8. The upper number is the corresponding time step.

2. Rayleigh number = 1e1:

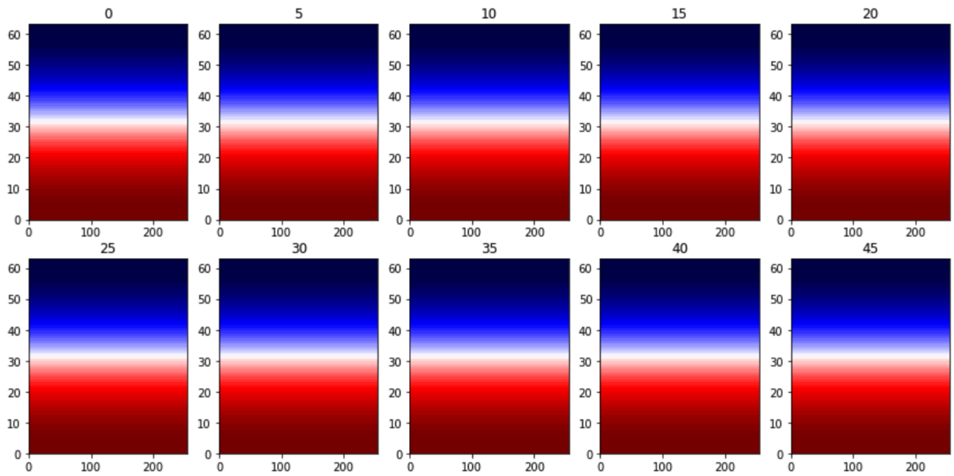

Fig. 2: Rayleigh-Benard convection with Rayleigh number = 1e1. The upper number is the corresponding time step.

When Rayleigh number is large enough (1e8), the results show the turbulence and eddies. However, when Rayleigh number is small (1e1), the initial random at middle level cannot trigger the convection. Even we artificially create a warm bubble at middle, the bubble still cannot trigger the convection:

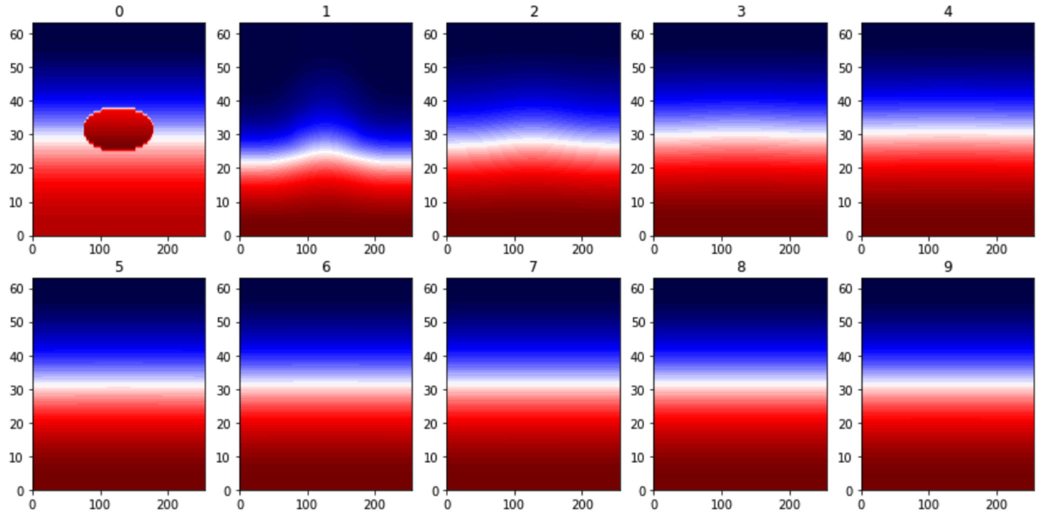

Fig. 3: Rayleigh-Benard convection with Rayleigh number = 1e1 but the initial setting is a warm bubble enforced. The upper number is the corresponding time step.

(b) Following question (a) and equation (2), plot the X(t) against Y(t). Discuss how the choice of Rayleigh number influences the periodicity of X(t) and Y(t).

$$\zeta = X(t)sin(\frac{\pi x}{L})sin(\frac{\pi z}{H})$$

$$T = Y(t)cos(\frac{\pi x}{L})sin(\frac{\pi z}{H}) - Z(t)sin(2\frac{\pi z}{H})$$

If we choose Rayleigh number equal to 1e1, the X and Y is expected to be zero after reaching balance. Therefore, I choose 1e5 to compare with 1e8:

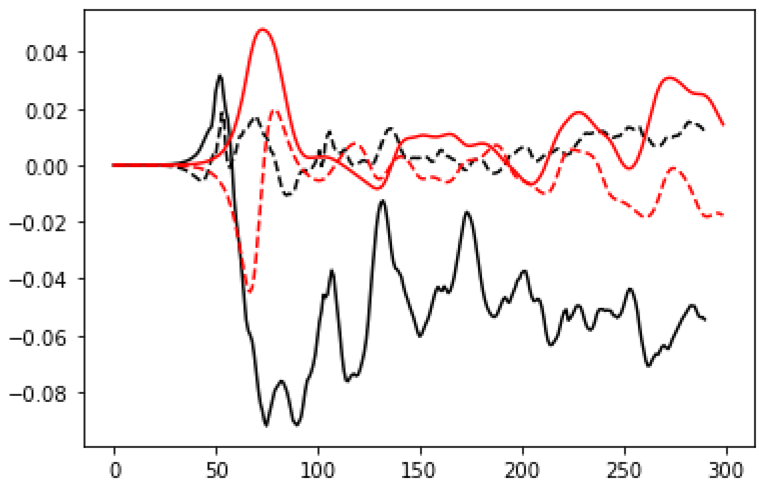

Fig. 4: The evolution of X (solid) and Y (dash). Black lines are 1e8 and red ones are 1e5.

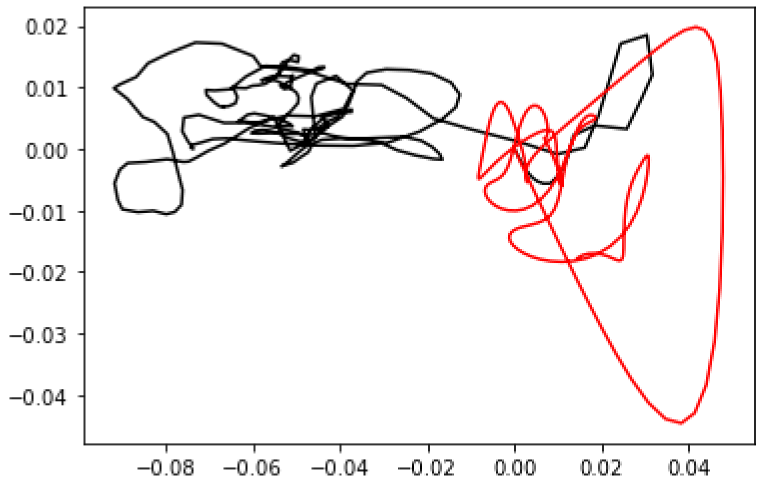

Fig. 5: X axis is X(t) and Y axis is Y(t)