

Macroturbulence Response to Vertical Stratification Change in an Idealized GCM

Pak-Wah (Packard) Chan¹ (pchan@g.harvard.edu), Pedram Hassanzadeh² and Zhiming Kuang^{1,3}

¹Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA, USA

²Department of Mechanical Engineering and Department of Earth, Environmental and Planetary Sciences, Rice University, Houston, TX, USA

³John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA

1. Eddy length scale

- Rossby radius

$$L_D = NH/f$$

$$N \uparrow \Rightarrow L \uparrow$$

- Rhines scale

$$L_\beta = \sqrt{\sqrt{EKE}/\beta}$$

$$N \uparrow \Rightarrow EKE \downarrow \Rightarrow L \downarrow$$

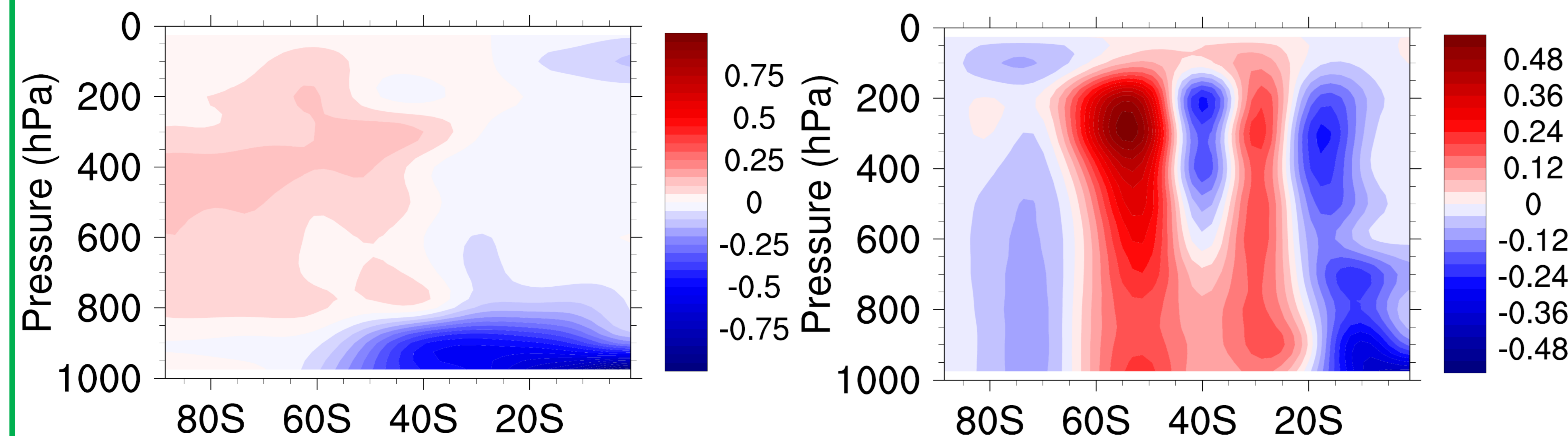
- What happens to the eddies, in well-controlled experiment with increased N and unchanged jet?

2. Increase N without changing the jet

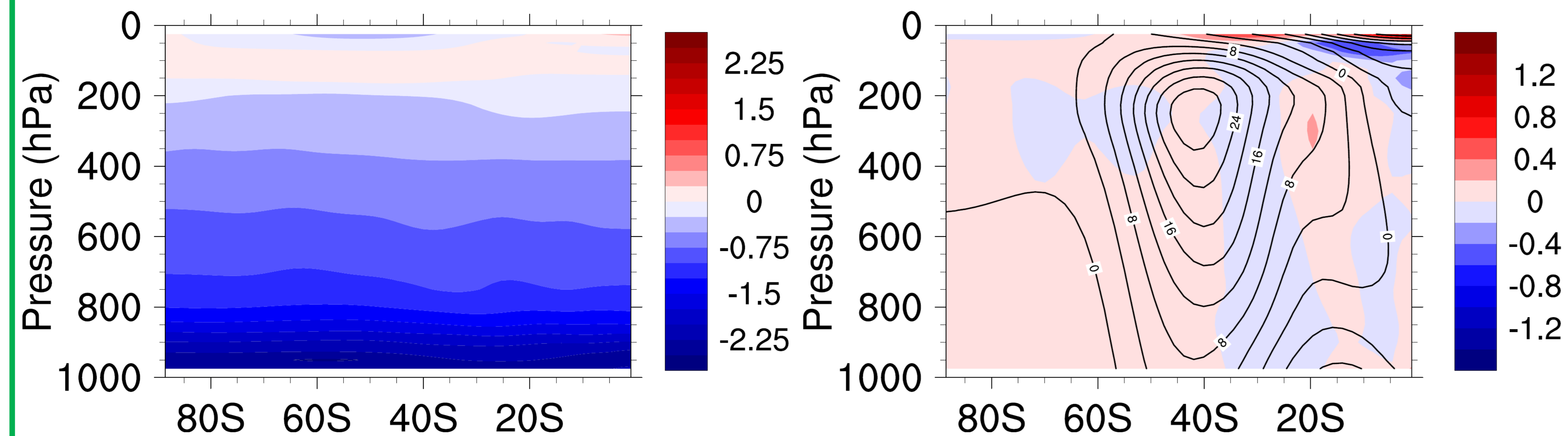
With linear response function of an idealized dry atmosphere (Hassanzadeh & Kuang, 2016), we can find the required forcing \mathbf{f}_0 to archive a prescribed mean state change \mathbf{x}_0

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{f} \Rightarrow \mathbf{f}_0 = -\mathbf{A}\mathbf{x}_0$$

Forcing in T (K/day) and U (m/s/day)



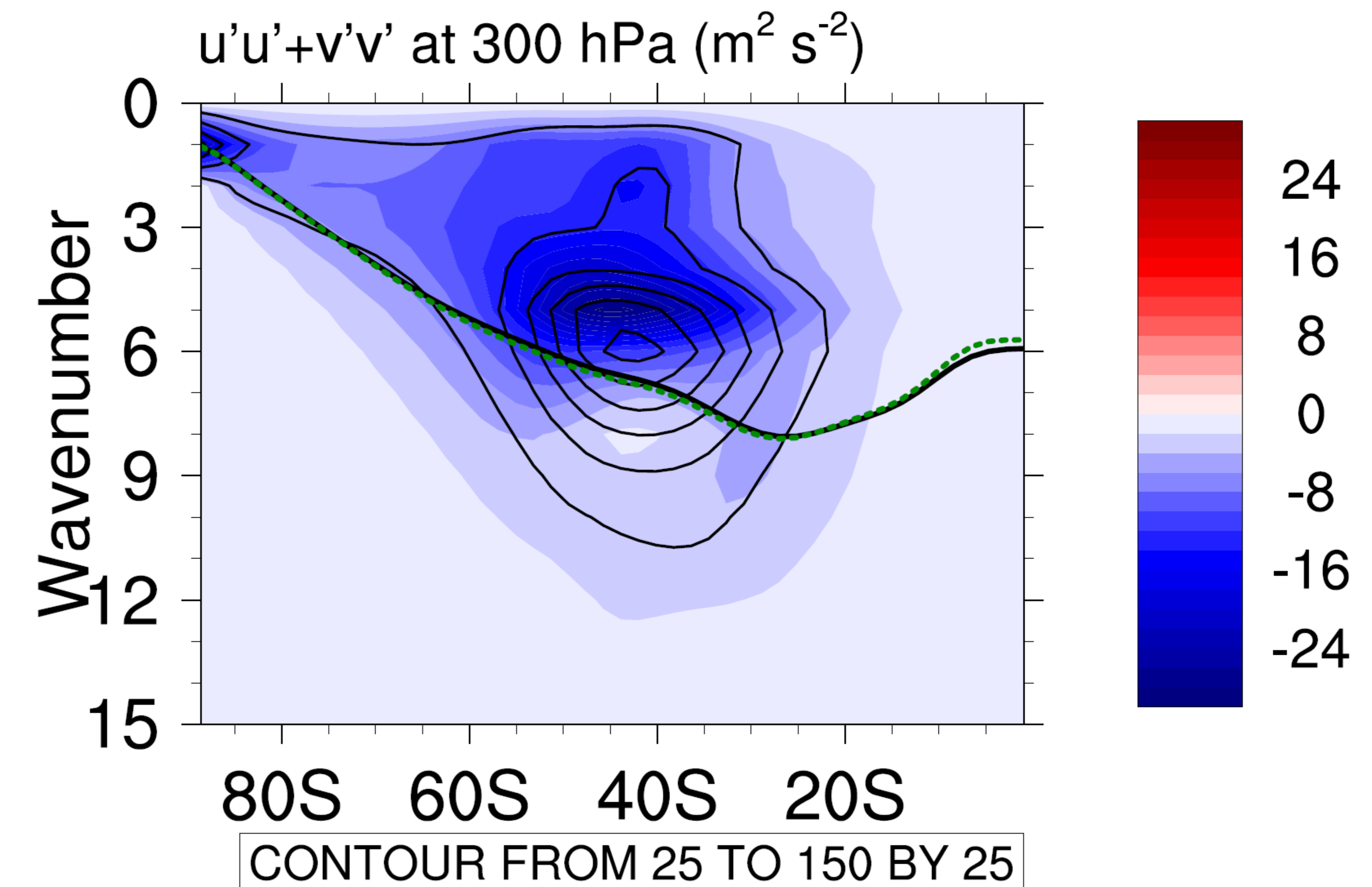
ΔT (K) and ΔU (m/s)



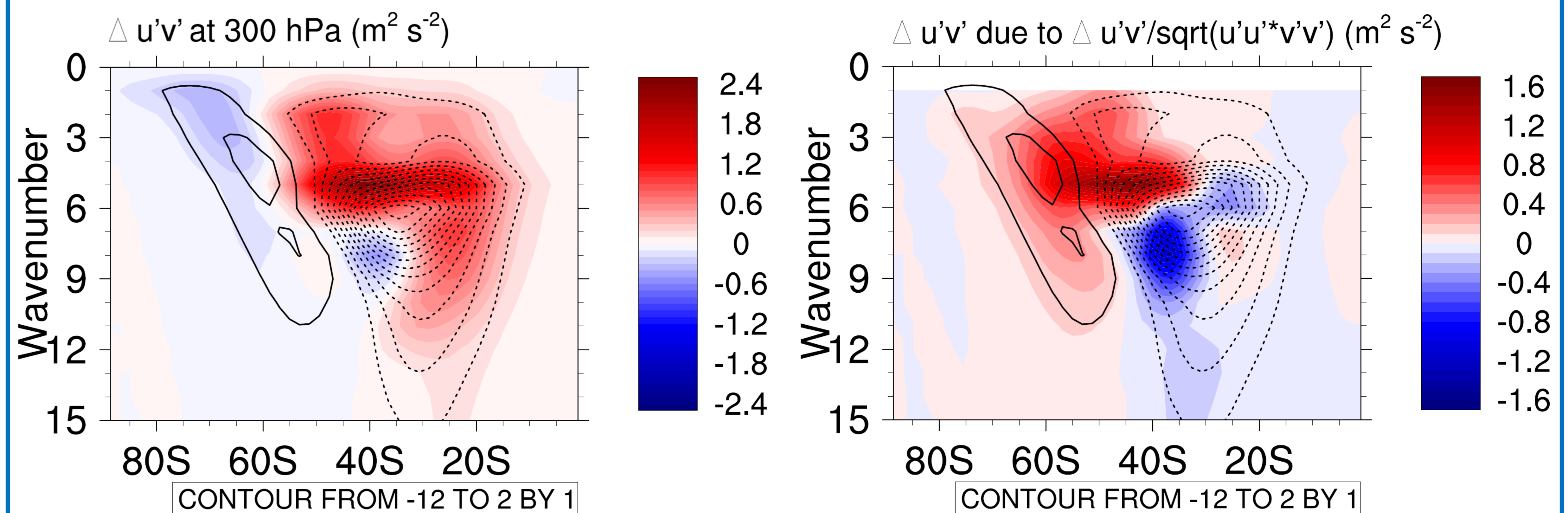
5. References

- Hassanzadeh, P., & Kuang, Z. (2016). The linear response function of an idealized atmosphere. Part I: Construction using Green's functions and applications. *Journal of the Atmospheric Sciences*, 73(9), 3423-3439.

3. Results



- Contour: control run; **Shading**: change; **Thick black line**: mean wavenumber in control run; **Dash green line**: mean wavenumber in perturb run
- $N \uparrow \Rightarrow L \downarrow$, agrees in sign with Rhines scale, but not Rossby radius



- Eddy kinetic energy decreases for all wavenumbers and latitudes
- $u'u'$ mostly weakens, except a local strengthening around zonal wavenumber 8 and 40°S, due to more correlated u and v

4. Conclusion

- Linear response function helps to increase N without changing the jet
- $N \uparrow \Rightarrow L \downarrow$, agrees qualitatively with Rhines scale