Investigating quasi-resonant Rossby waves with an idealized general circulation model

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Quasi-resonance proposed by Petoukhov et al. (2013)

Rationale

- Increases in NH summer extremes aren't purely thermo
- Dynamics matter→propose quasi-resonance mechanism

Quasi-resonant amplification (qualitative idea)

1. Start w/ *unforced* linear barotropic vorticity equation
2. Certain mean flow structures (*waveguides*) can trap waves
3. Waves therein won't escape→they grow to large amplitude

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Towards a systematic test of the QRA hypothesis

Quasi-resonance derivation involves many assumptions

- Whether they are satisfied should be tested
- High-end models/data not ideal for this purpose
  - Limited ability to directly control zonal mean state
  - If QRA is true, much of their complexity is superfluous

Suitably idealized GCM should address these problems

- Dry primitive equations dycore (GFDL), Newtonian relaxation thermal forcing
- Control mean state via iterative generation of T_{eq} (Chang 2006)

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What mean flows should trap Rossby waves?

In words

- Local maxima in the stationary wavenumber k_s^2 (basically)

In math

- For free quasi-stationary Rossby waves, meridional wavenumber l given by $a^2 l^2 = k_s^2 - k^2$
  - k is (specified, dimensionless) zonal wavenumber
  - k_s defines the basic state
- Meridional group velocity $c_{gy} \propto l$
  - Need real l for meridional propagation
    - So local maxima in k_s^2 can trap waves
- $$k_s^2(\phi) = \frac{2\Omega a \cos^3\phi}{U} - \frac{\cos^2\phi}{U}\frac{\partial^2 U}{\partial \phi^2} + \frac{\sin\phi\cos\phi}{U}\frac{\partial U}{\partial \phi} + 1$$
- Pick k_s^2, solve numerically for U (at equivalent barotropic level)

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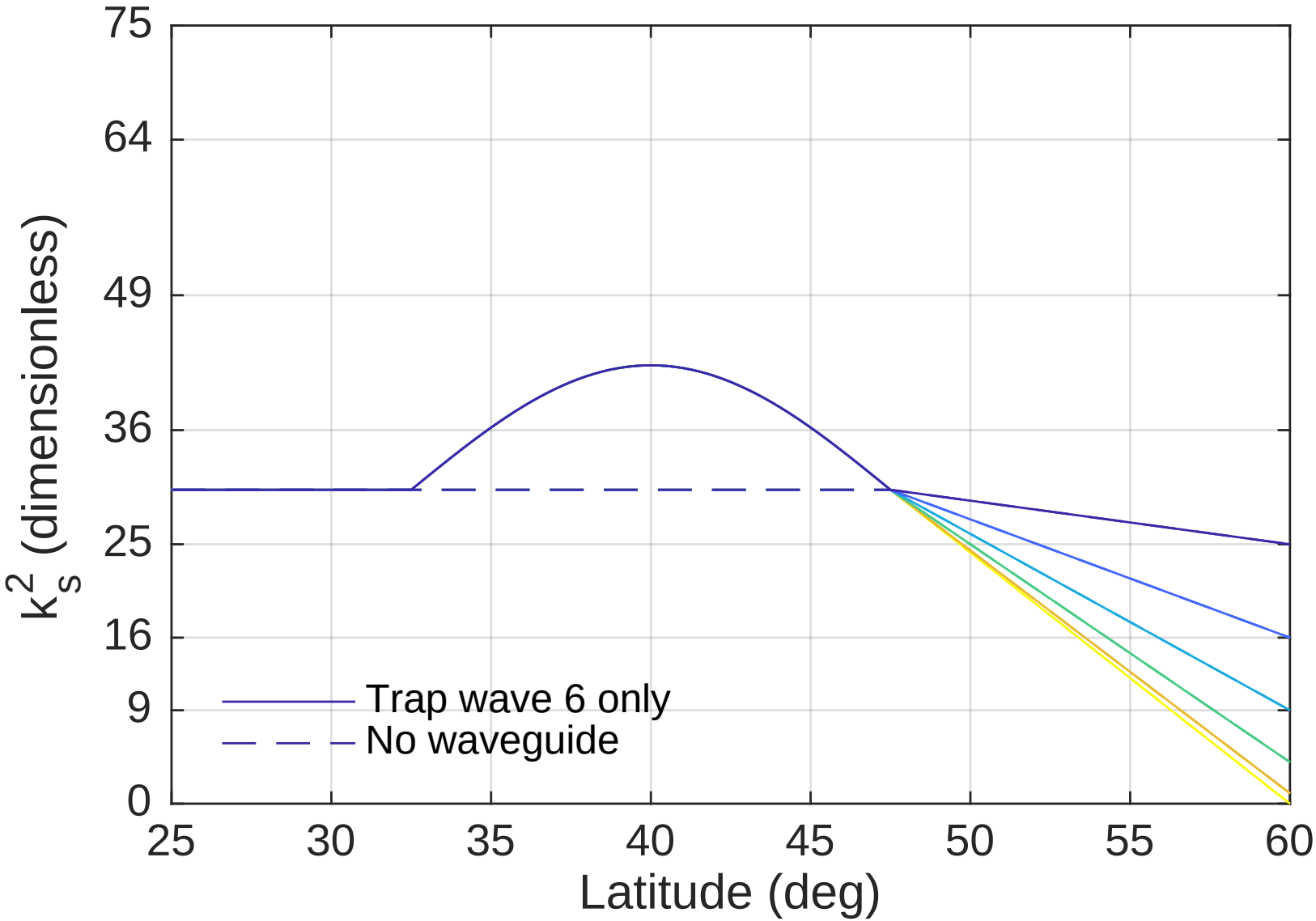
Idealized k_s^2 Profiles



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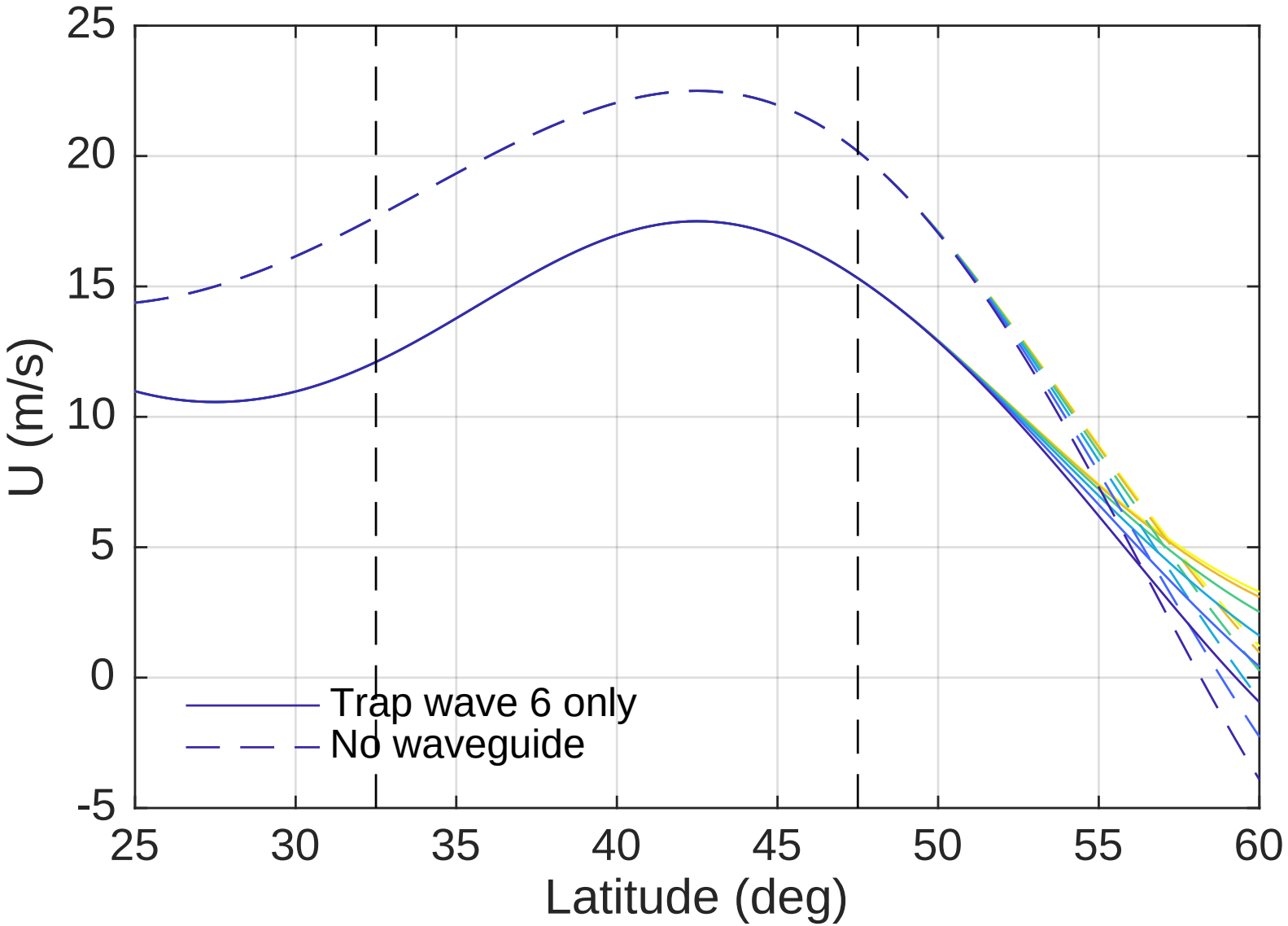
Idealized Jet Profiles



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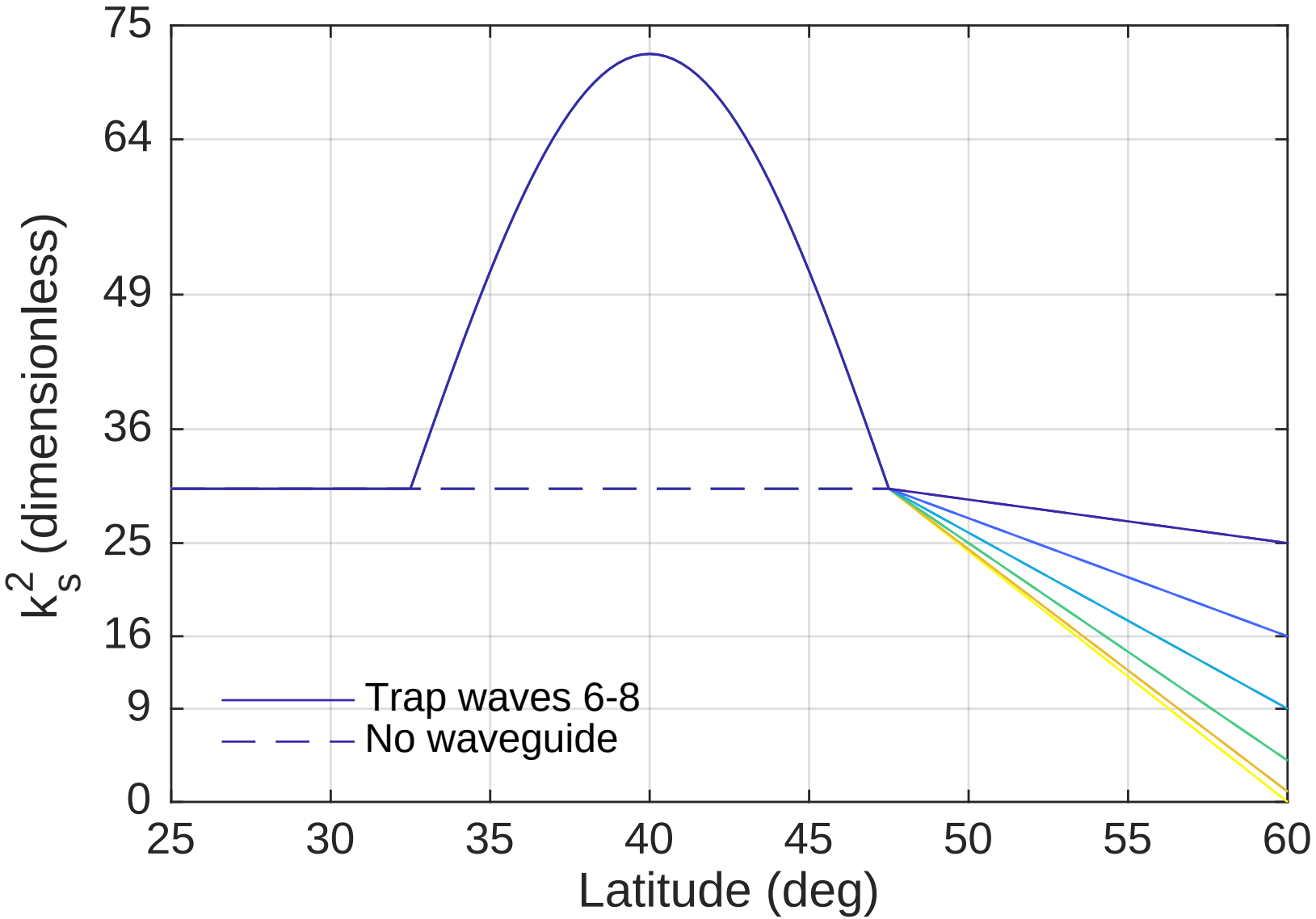
Idealized k_s^2 Profiles



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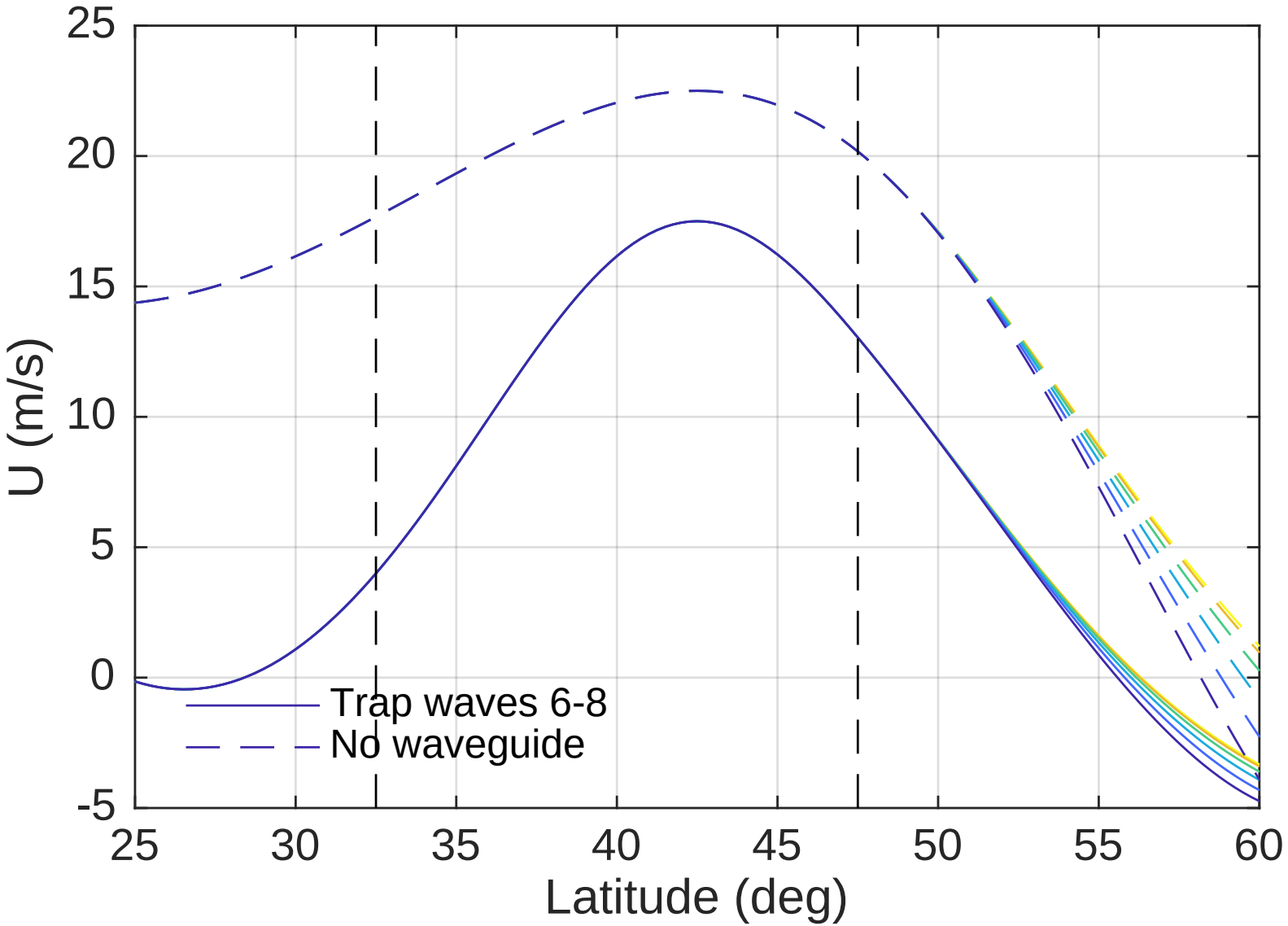
Idealized Jet Profiles



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Summary/Next Steps

Purpose

- Test quasi-resonant Rossby wave hypothesis using idealized GCM

Next steps

1. Complete $U(\phi)$ profiles to cover all latitudes
2. Generate thermal structures to cover all latitudes + pressures
3. *See if GCM can produce these with necessary accuracy!*

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