An overview of gravity wave tuning in WACCM7

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Background on the spectral element dynamical core

- CESM's workhorse model
  - Intended to be the central configuration of CESM for future intercomparison projects, community use, and science
- Spectral element dynamical core
  - Quasi-uniform grid spacing
    - *Finite volume grid crunch at the poles*
  - Supports regional refinement
  - Superior computational scaling and throughput
    - *Finite volume limited by the need for each core to see a full longitude strip*

Finite Volume (FV)
[regular lat-lon]

Spectral Element (SE)
[cubed-sphere]

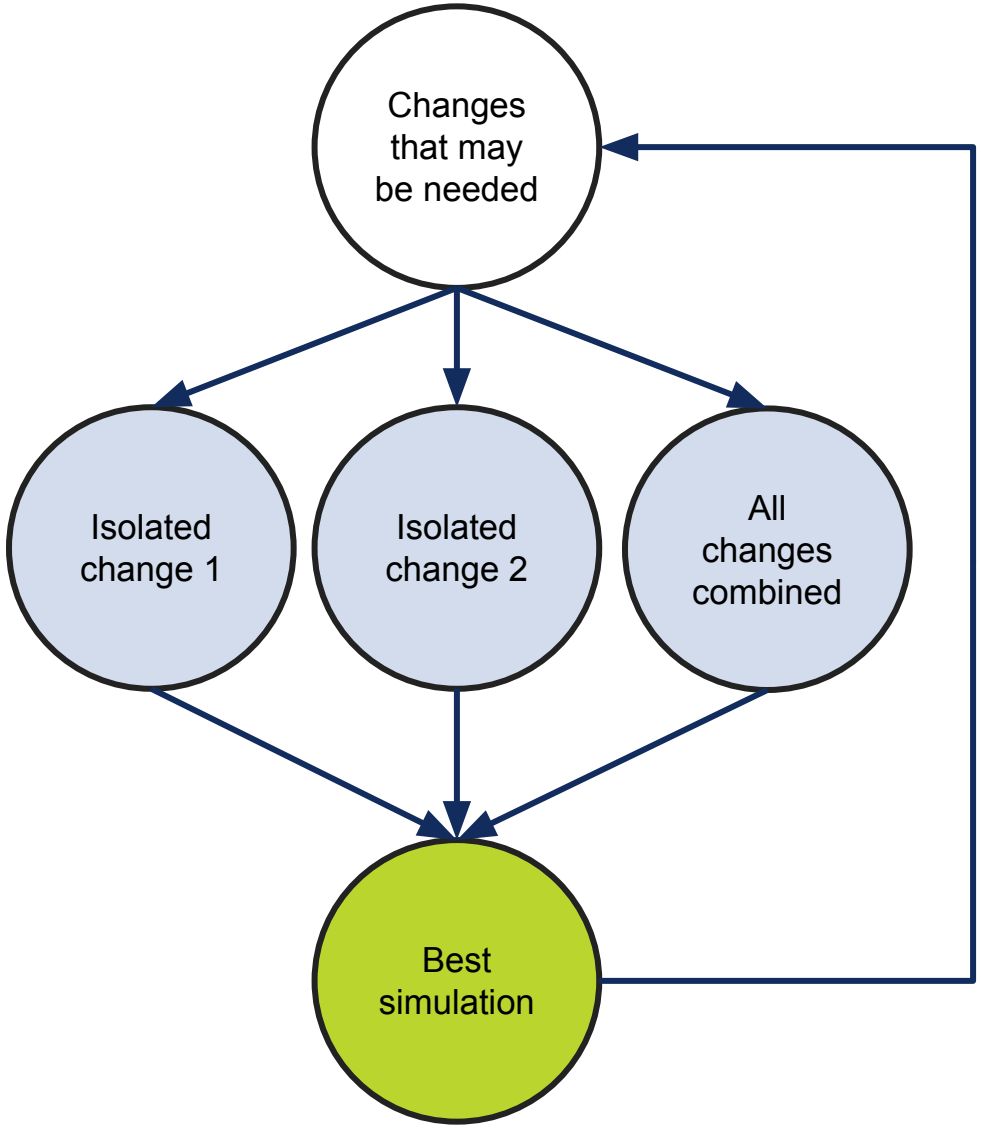
Background on the spectral element dynamical core

- Spectral element dynamical core presents unique challenges
  - Gravity wave tuning on a quasi-uniform grid
  - Less diffusive than finite volume dynamical core
- Workhorse configuration presents unique benefits
  - WACCM inherits tropospheric tuning
  - Only need to focus on gravity wave and sponge layer tuning

Finite Volume (FV)
[regular lat-lon]

Spectral Element (SE)
[cubed-sphere]

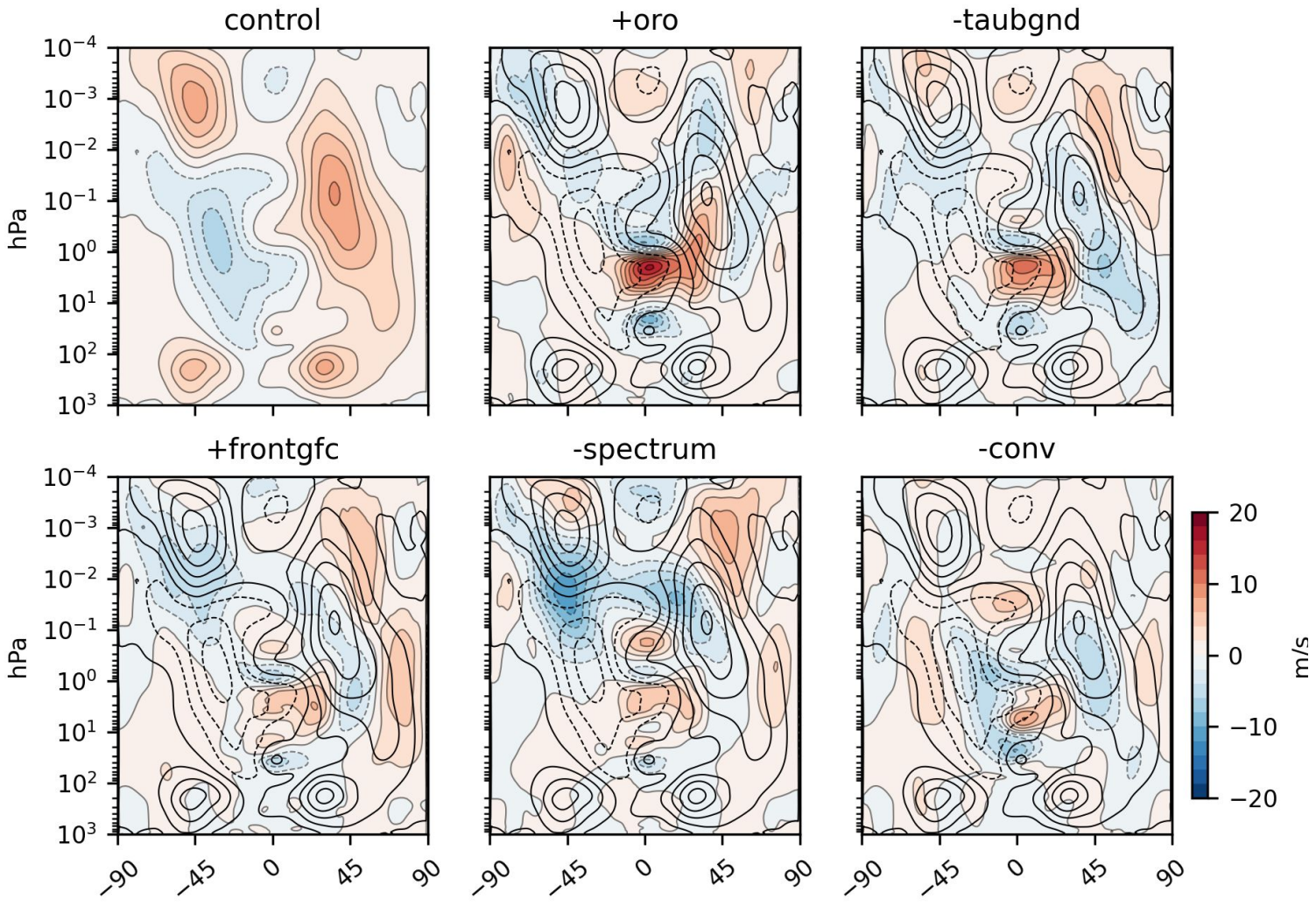
Rapidly tuning gravity wave parameters



- Key parameters
  - *Orographic gravity wave forcing*: effgw_rdg_beta(_max)
  - *Convective gravity wave forcing*: effgw_beres
  - *Frontal gravity wave forcing*: frontgfc, taubgnd, front_spectrum_width*
- General approach
  - Identify 2-4 changes that may be needed based on last round's best simulation
  - Perform one simulation for each change, with only that change ("isolated")
  - Perform one simulation with all changes ("combined")

*New, adjusts the half-width of the spectrum

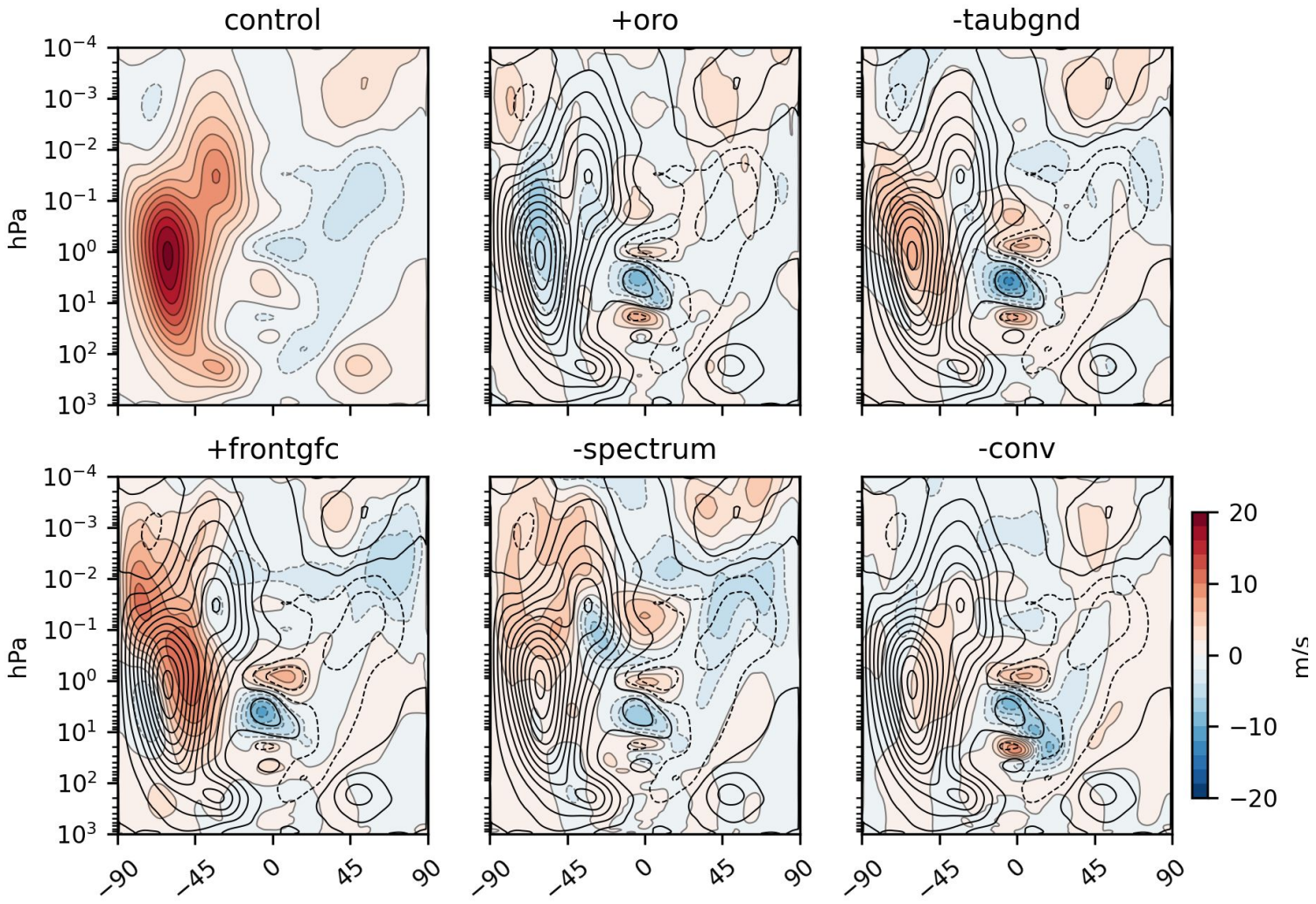
What does each parameter do to the zonal wind in DJF?



- **All project onto the tropical winds**
- **Weakens vortex**: +oro, -taubgnd
- **Shifts vortex**: +frontgfc, -spectrum, -conv
- **Shifts/strengthens mesopause**: -taubgnd, +frontgfc, -spectrum

+oro	*Increase oro forcing (1.3 to 1.6)*
-taubgnd	*Reduce background frontal forcing (1.3 to 1.1e-15)*
+frontgfc	*Increase frontal trigger threshold (1.25 to 1.5e-5)*
-spectrum	*Narrow frontal spectrum (30 to 24 m/s)*
-conv	*Reduce convective forcing (0.8 to 0.55)*

What does each parameter do to the zonal wind in JJA?



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What does each parameter do to the mesopause?

- **All except convective tuning project onto the mesopause**
- **Improves the mesopause vertical structure**: -spectrum
- **Cools the mesopause**: -taubgnd, + frontgfc

+oro	*Increase oro forcing (1.3 to 1.6)*
-taubgnd	*Reduce background frontal forcing (1.3 to 1.1e-15)*
+frontgfc	*Increase frontal trigger threshold (1.25 to 1.5e-5)*
-spectrum	*Narrow frontal spectrum (30 to 24 m/s)*
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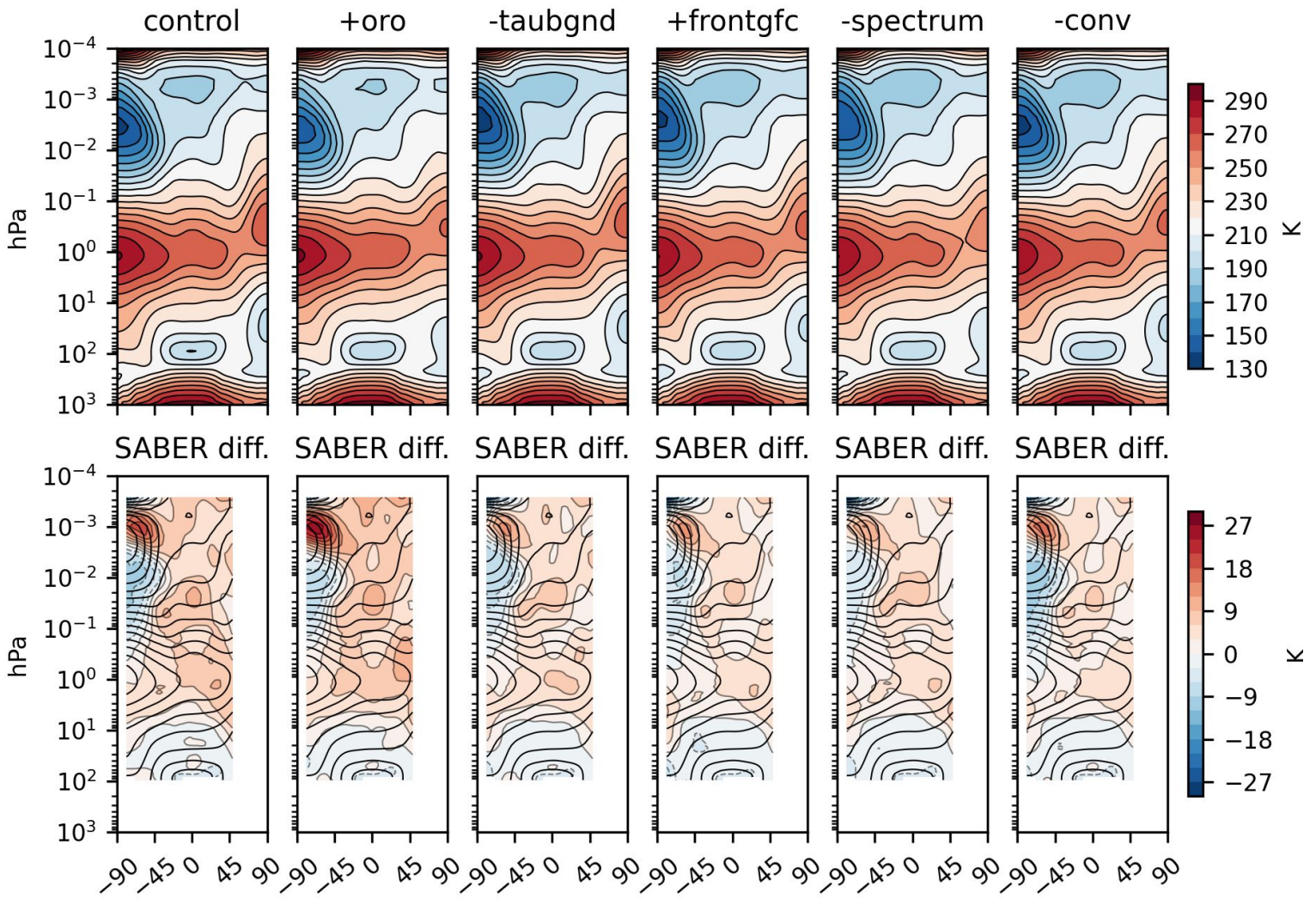

Summary

- Adjusting gravity wave parameters is not always additive
  - Wave filtering
  - Feedbacks with the meridional circulation and chemistry
- Implementing Holtslag-Boville diffusion above CLUBB top stabilizes WACCM7
- Some issues, like the SH vortex tilt in observations, may be associated with horizontal gravity wave propagation (do we try to tackle this bias, or leave it be)
- New parameter, frontal wave spectrum half-width, replaces the existing hard-coded frontal wave spectrum half-width
  - More precise control of mesopause behavior
- Impacts of each parameter - and how specific model biases can be addressed - will be put into a white paper for internal and external community use
- This seems like a good space for an optimization/machine learning approach