Implementing a parameterization of convective gravity waves due to the obstacle effect in CAM/WACCM

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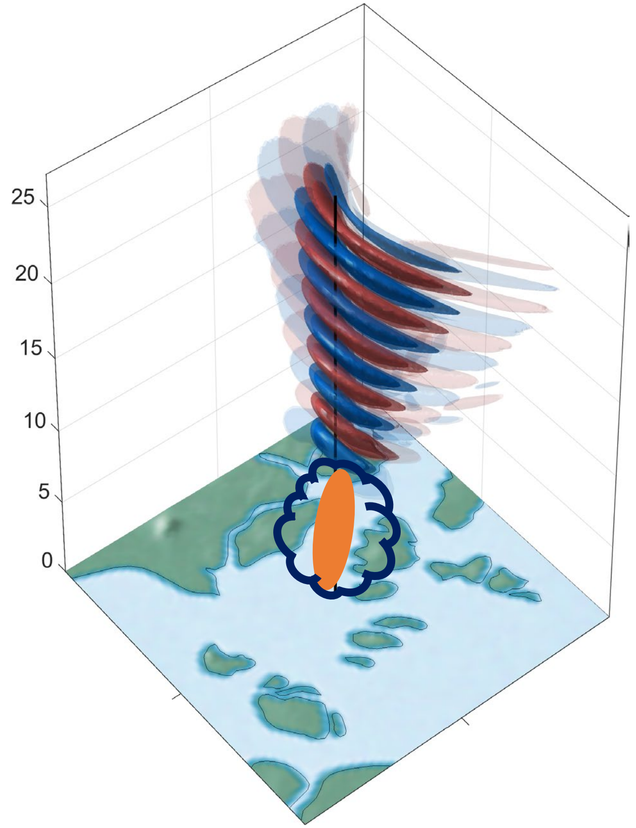

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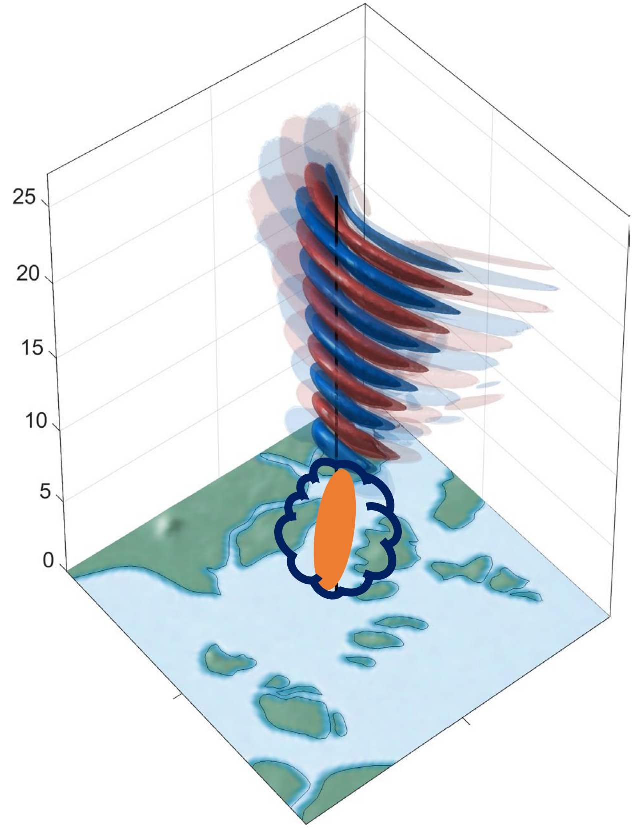
Moving Mountain Mechanism

Overview:

- Waves are stationary relative to the cloud motion
- Shear at the top of latent heating generates waves with this mechanism - analogous to a mountain wave
- Evidence from numerical and observational studies that these waves have larger amplitudes -> more momentum flux
- The parameterization is based on a linear model for waves emitted from stationary heat sources described in Beres et al. (2004)
- It uses a lookup table approach where the lookup table is a function of wind speed and latent heating depth



The hope:

Parameterization will provide drag at low phase speeds which may improve representation of QBO in lowermost stratosphere

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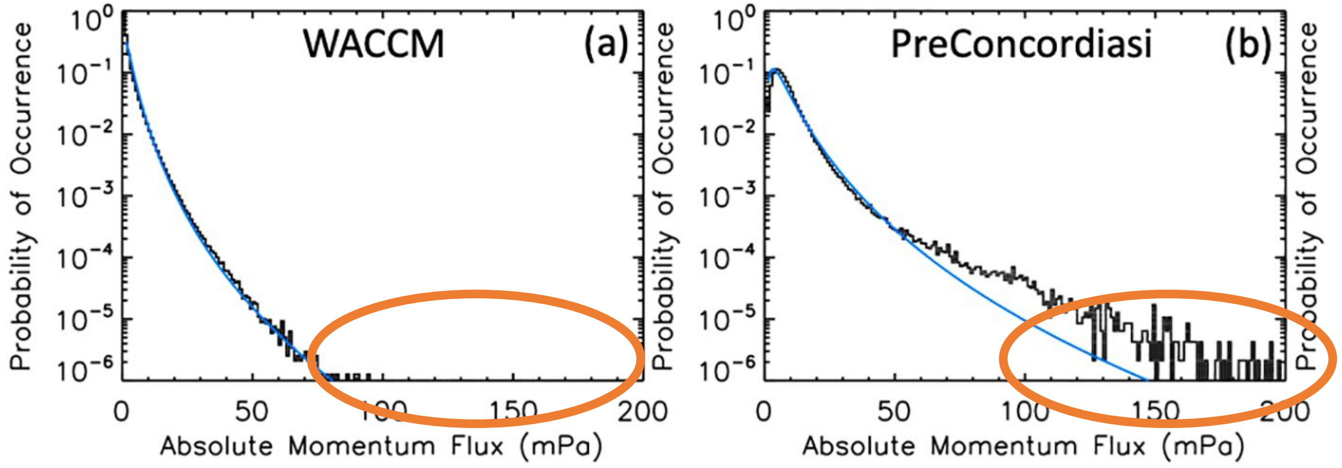
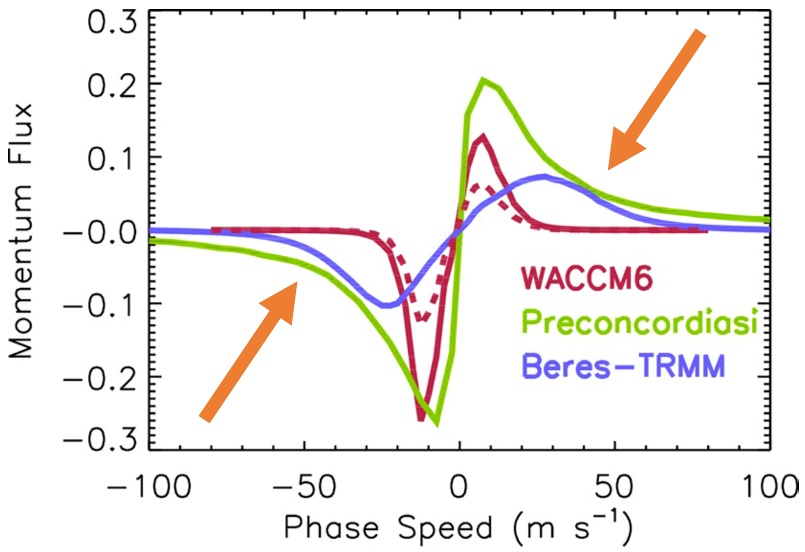
Comparison of Parameterized and Observed Momentum Fluxes



Large momentum fluxes >100mPa are missing in WACCM



Realistic sources lead to realistic parameterization of high-speed GW spectrum, but low phase speeds are missing

Alexander, M. J., Liu, C. C., Bacmeister, J., Bramberger, M., Hertzog, A., & Richter, J. H. (2021). Observational validation of parameterized gravity waves from tropical convection in the Whole Atmosphere Community Climate Model. *J. Geophys. Res.: Atmos.*, 126, e2020JD033954. https://doi.org/10.1029/2020JD033954

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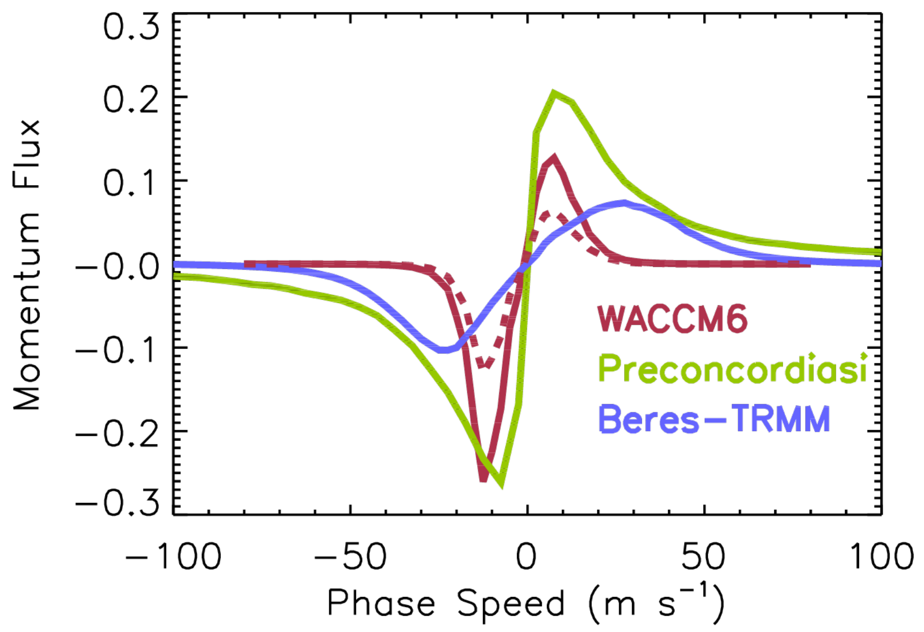

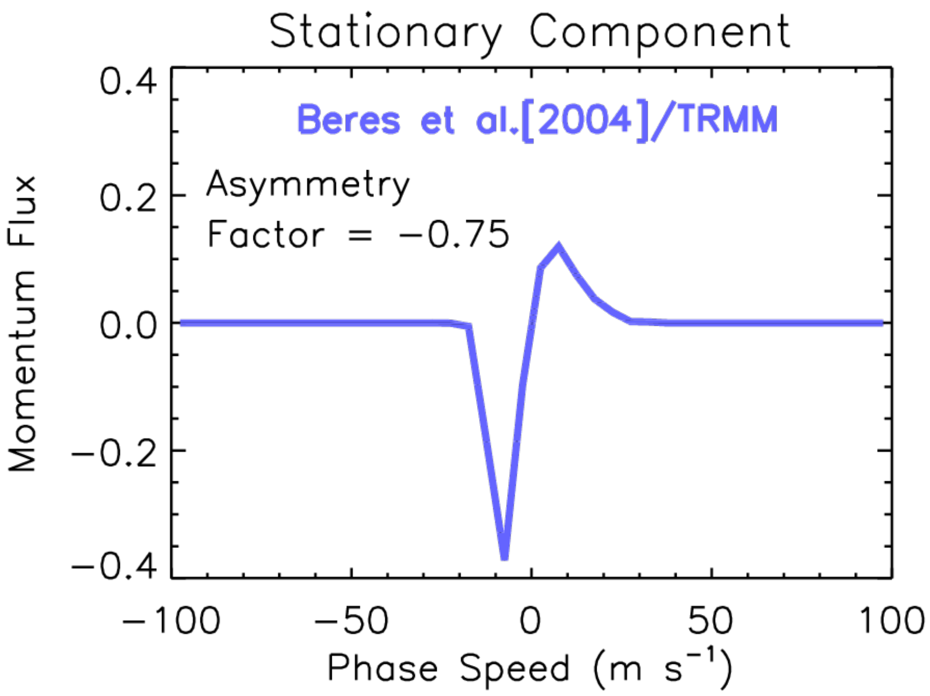

- TRMM describing the convective sources and ERAi describe the winds
- Mechanism provides momentum fluxes at low phase speeds (5-10 m/s) where WACCM needs them
- Large amplitudes might force QBO descent to lower altitudes?
- Enhanced westward wave flux for improving easterly phase descent?

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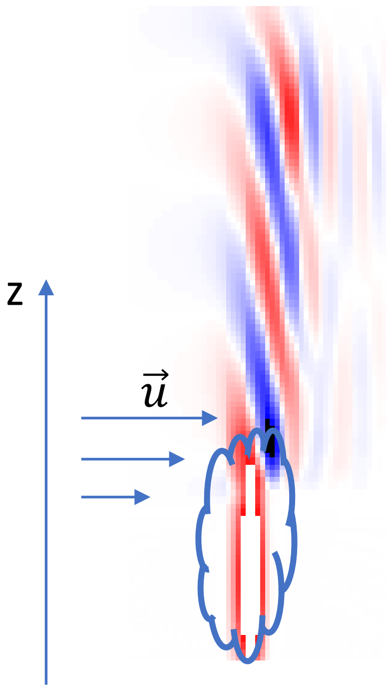
Input parameters of the parameterization

Assumption: convective cell moving in the direction and with speed of U_{700hPa}

- Input parameters:
    - Latent heating depth
    - Wind at top of latent heating relative to cell motion
    - Peak heating strength
    - CF = 5% (areal fraction of convective plumes in the grid cell)

$Q_0 = Q/CF$

$M_0(c_j) = CL_\tau Q_0^2 K(c_j)$



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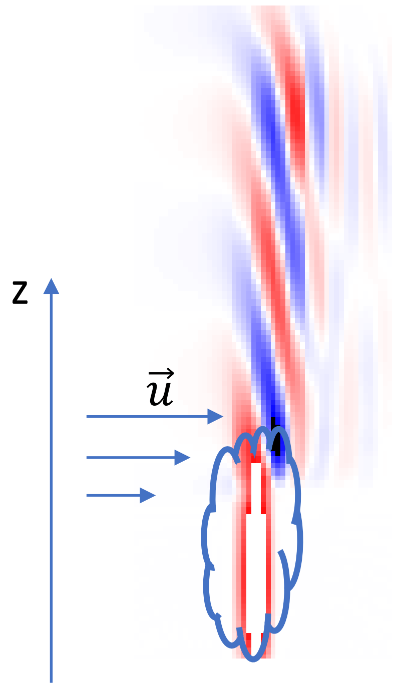
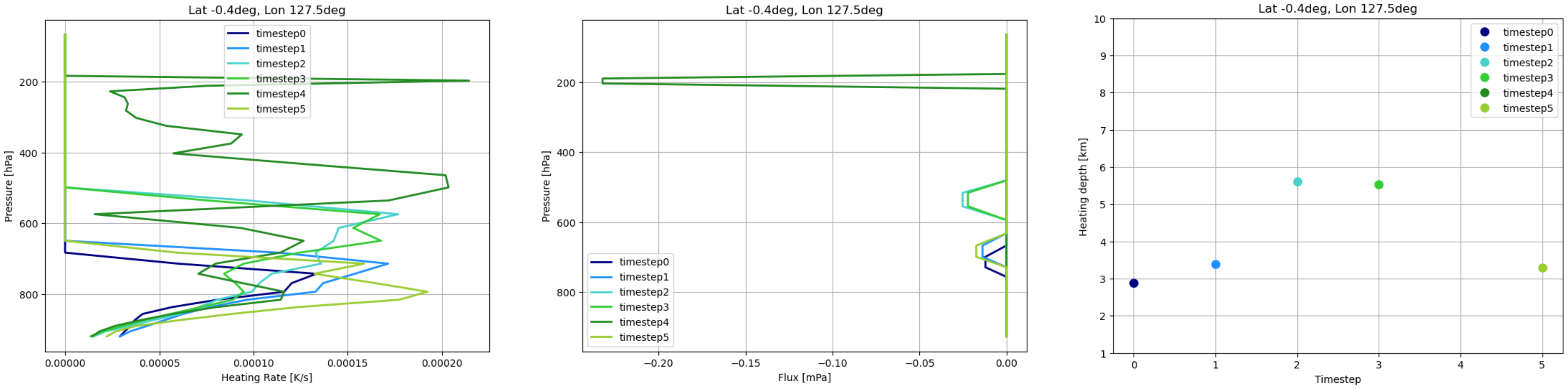
Differences to existing Beres scheme

- Relevant wind is in the frame of reference moving with the convective plume
- Wind shear at the top of the convective cell
- Wave propagation direction is opposite to the relevant cloud top wind
- Momentum flux is not a spectrum of phase speeds, but a single phase speed

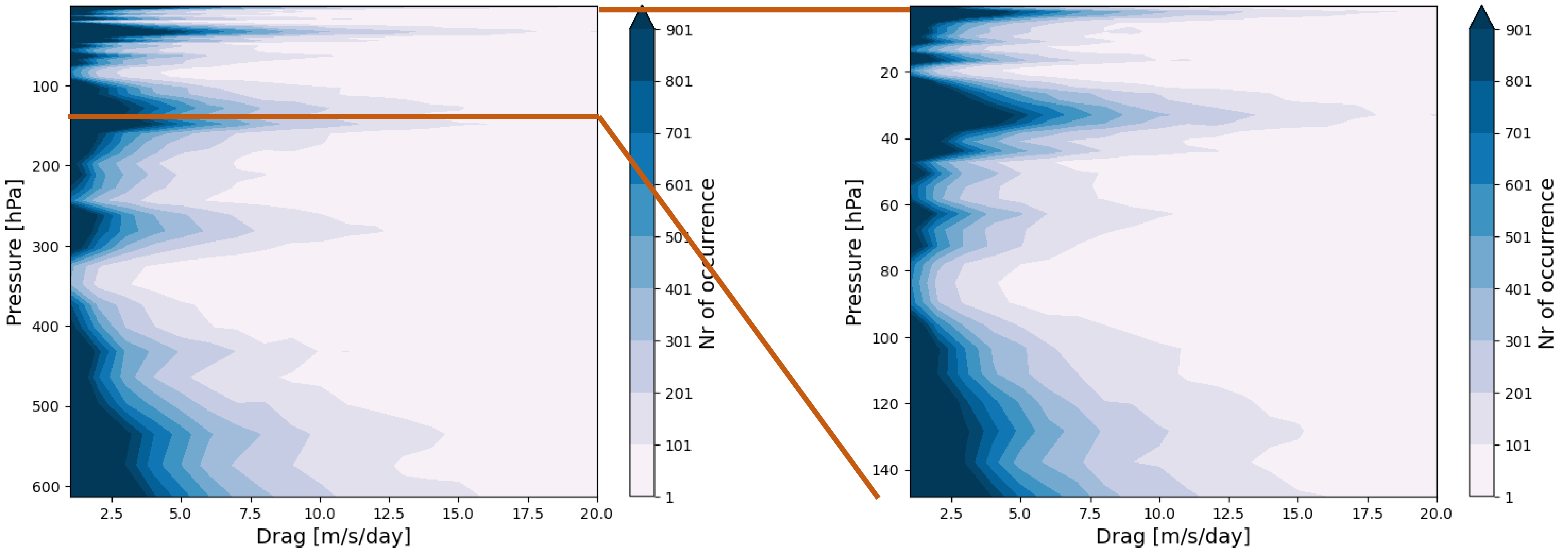


Differences to “Boundary layer MM scheme”

- Use Zhang–McFarlane scheme as latent heating input
- Steering level at 700hPa
- Launch level is top of latent heating:



First results – Vertical Zonal Drag Distribution



- Input drag in troposphere and stratosphere
- Additional drag in stratosphere might improve QBO in lowermost stratosphere

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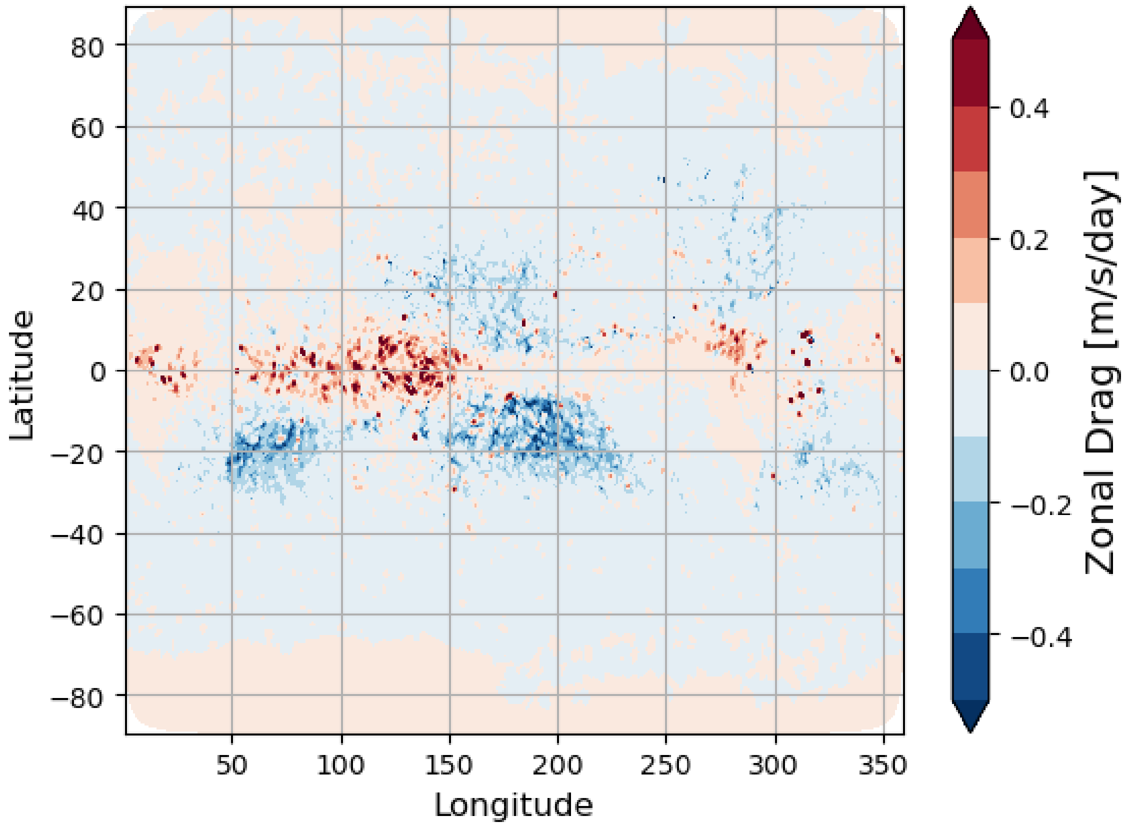
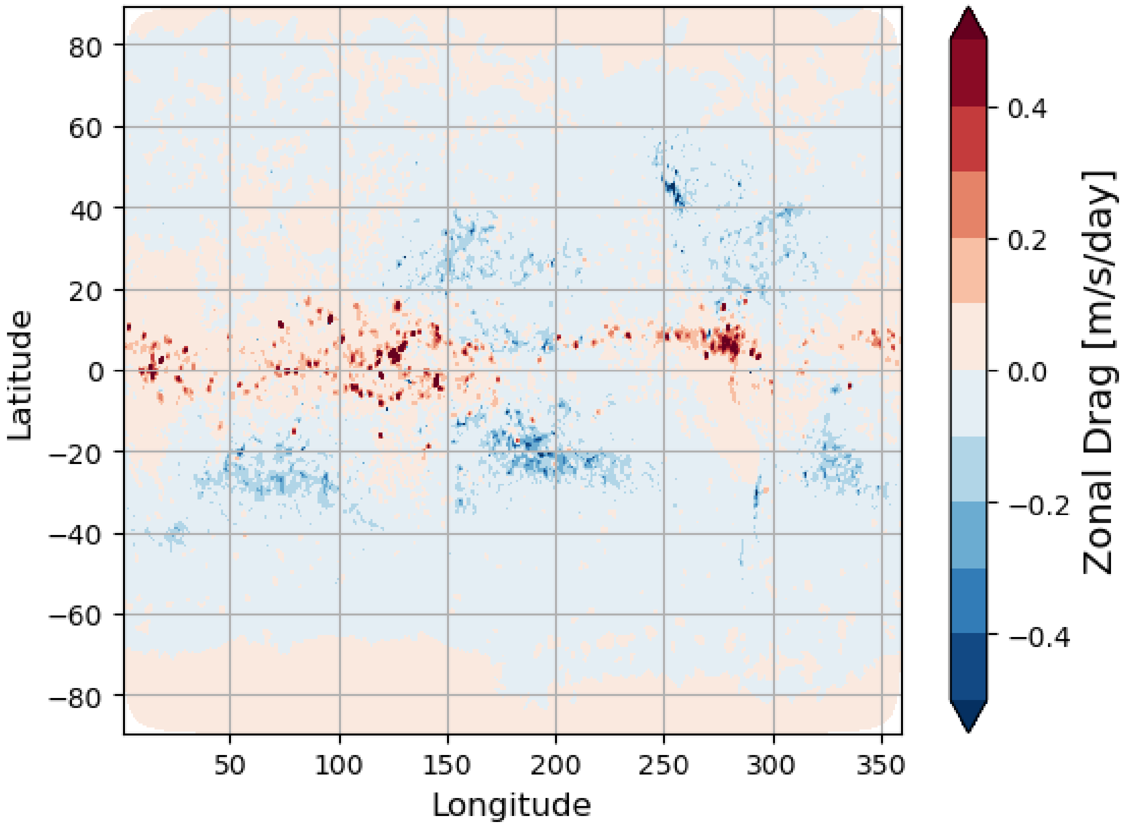
First results – Global Distribution

77 hPa



50 hPa



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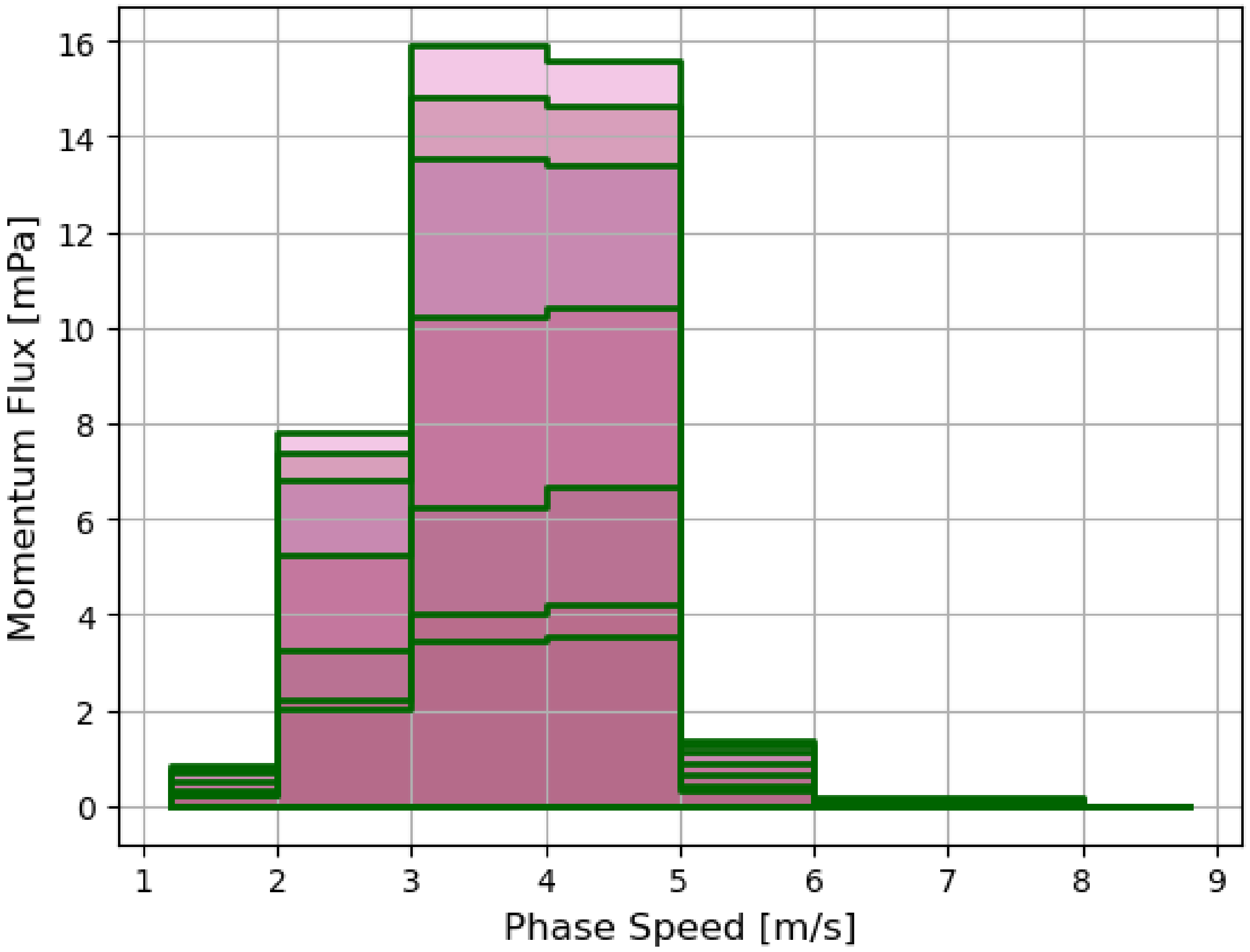
First results – Momentum Flux Distribution



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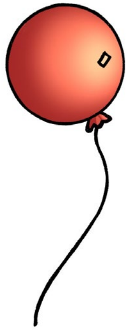
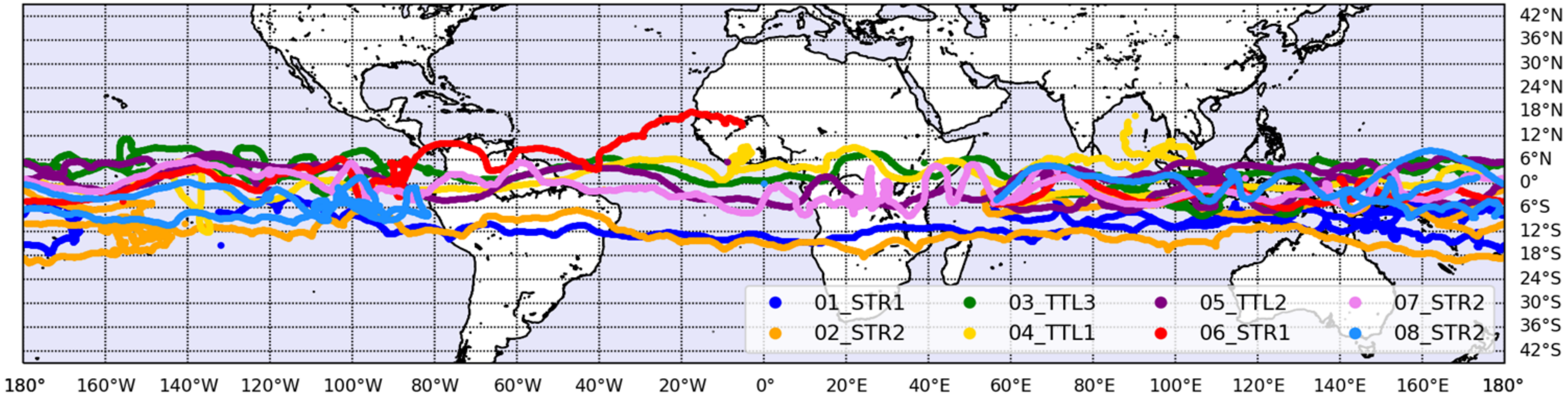
Observational Constrains – Strateole 2

- Just finished 10 year run
- Still need to tune the parameterization
- Constrains for tuning:





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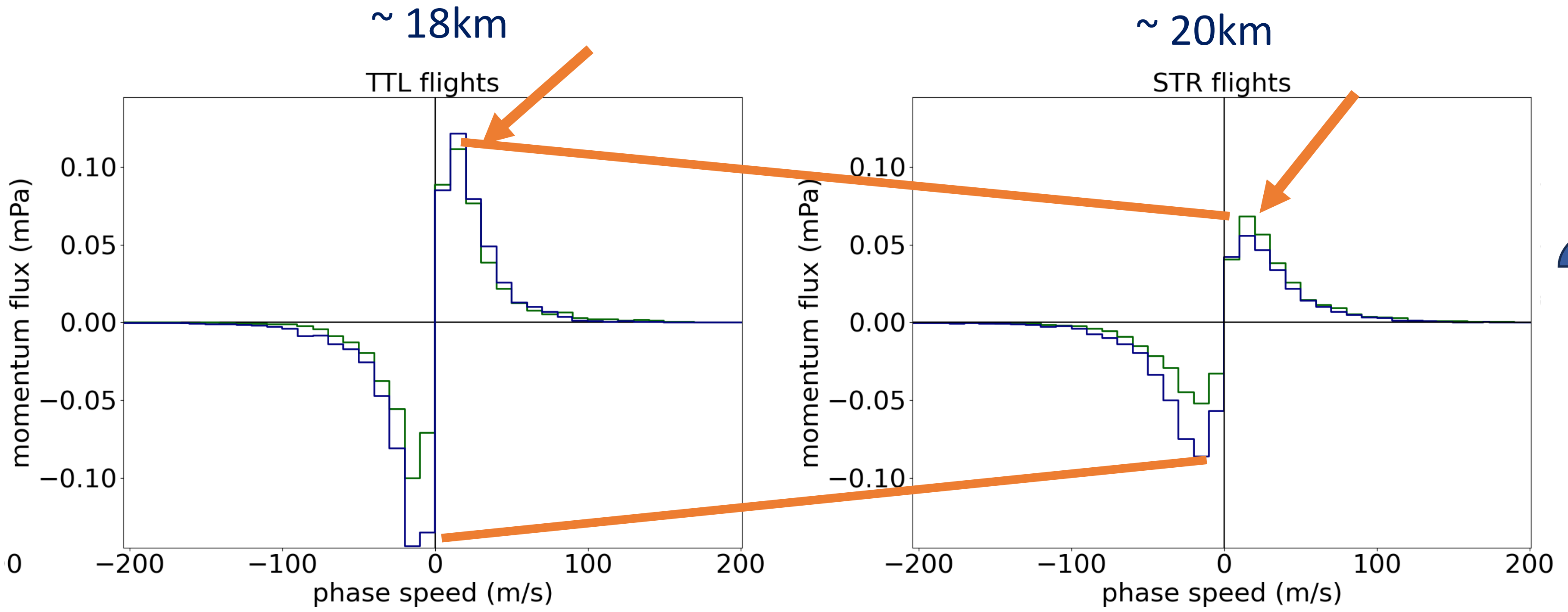
Observational Constrains – Strateole 2



$$M_0(c_j) = CL_\tau Q_0^2 K(c_j)$$

- Filtering at low stratospheric altitudes of waves with low phase speeds
- We will us these observations to tune the parameterization

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Conclusions

- We have implemented the moving mountain mechanism as additional convective gravity wave source
- We use a lookup table approach based on Beres et al. (2004)
- Drag mostly distributed
    - around equator and SH
    - Upper troposphere and mid stratosphere
- No tuning yet, but constrains provided by balloon measurements

Next Steps

- Analyze impact of moving mountain drag on QBO and SH stratospheric vortex
- Constrain tuning of parameterization with balloon measurements
- Experiment with combination of CLUBB and ZM heating
- Experiment with variable steering wind level (at the moment set to 700hPa)

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Thank you!