



# Stratospheric wind biases in new model and possible improvement with new GW source

**NCAR:** Isla Simpson, Simone Tilmes, Rolando Garcia,  
Adam Herrington

**CORA/NWRA:** Martina Bramberger, Joan Alexander

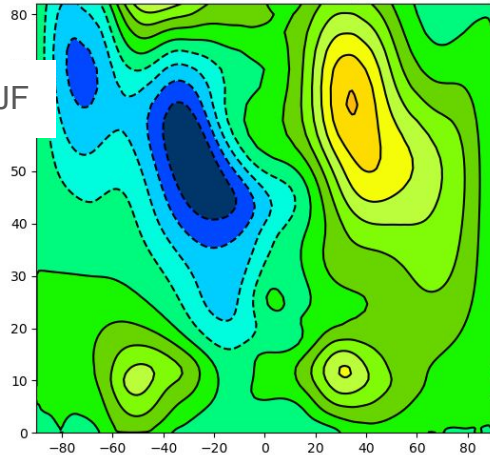
*AMWG Winter Meeting. February 12, 2024*

# Model runs discussed here

- WACCM6 FWHIST
  - CMIP6 contribution
  - FV dycore 1°, L72 (Dz~1200m in UTLS, top ~140km)
  - Full interactive chemistry
- CAM7 FMTHIST control
  - Close to current development version (CLUBB-L)
  - SE-physgrid dycore (n30pg3), L93 (Dz~500m in UTLS, top~85km)
  - “Prognostic GHG” configuration
- Tests of new GW source in CAM7 FMTHIST

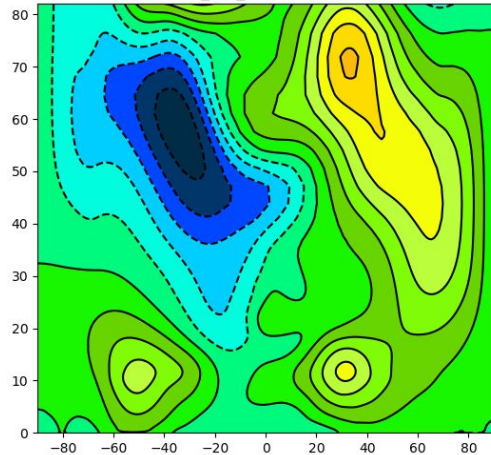
# WACCM6 FWHIST L72

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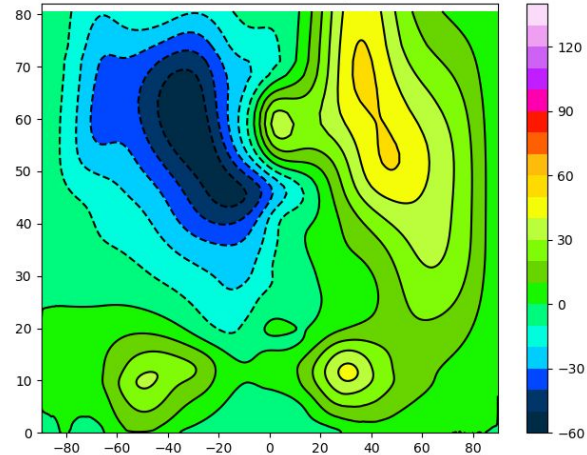
# CAM7 FMTHIST L93 Control

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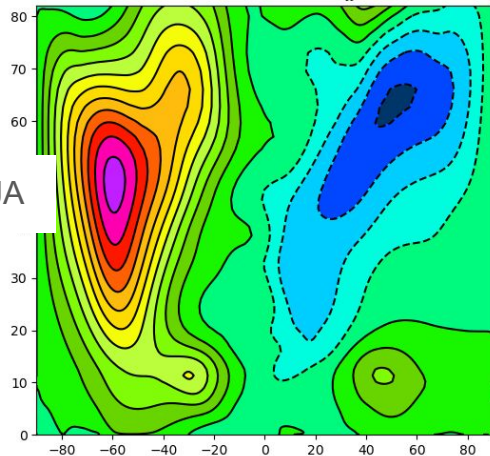


# ERA5

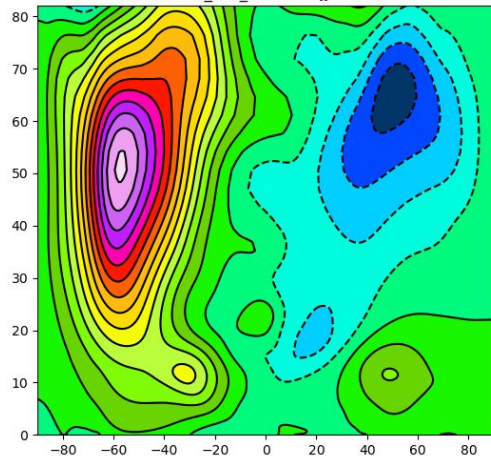
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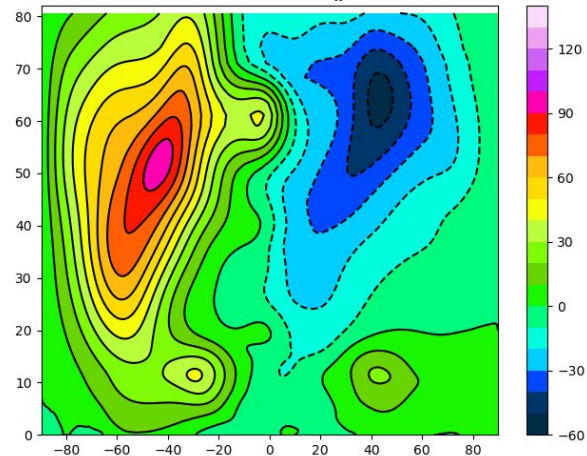
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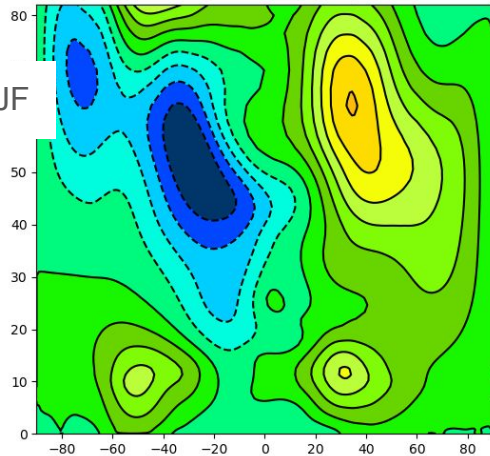


Validation <ERA-5> JJA



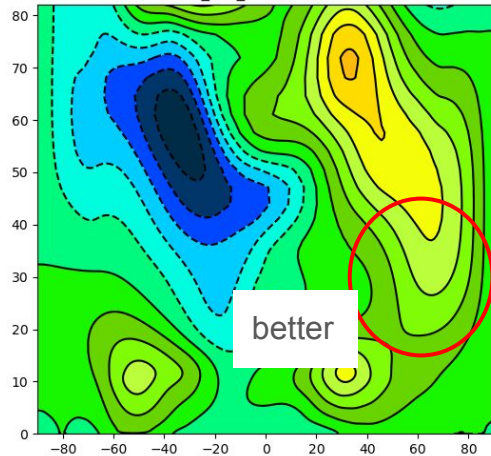
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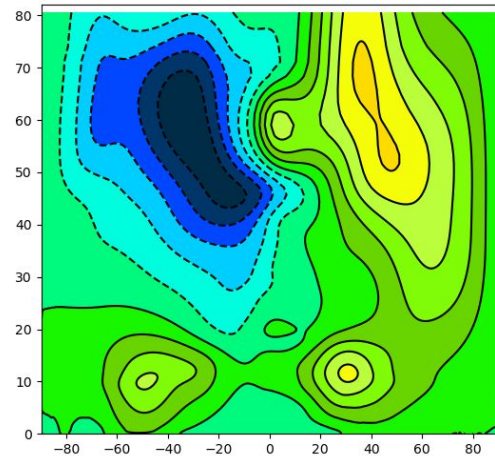
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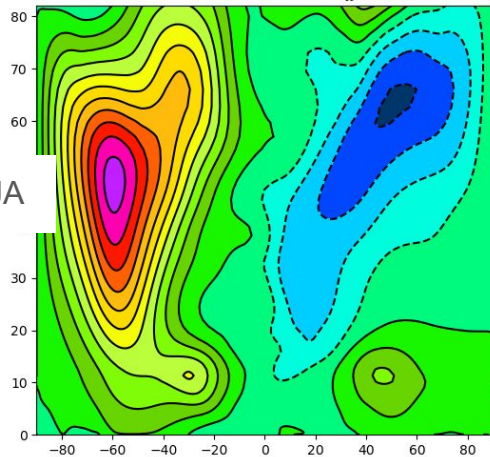


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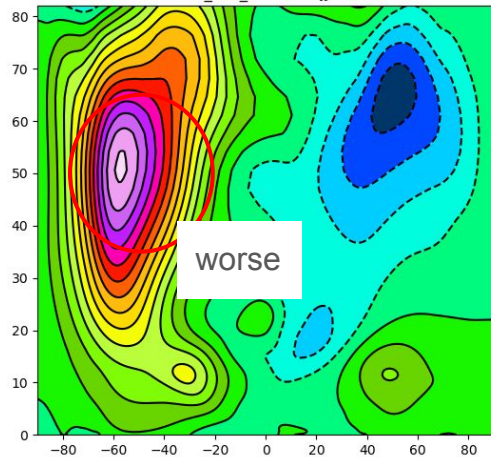
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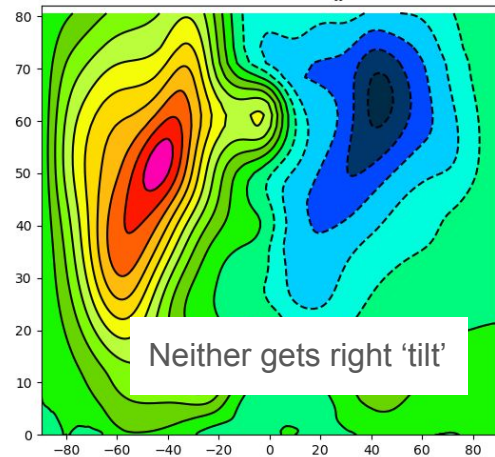
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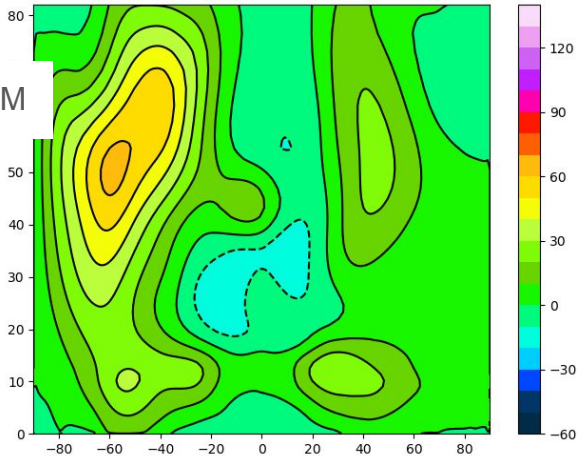


Validation <ERA-5> JJA



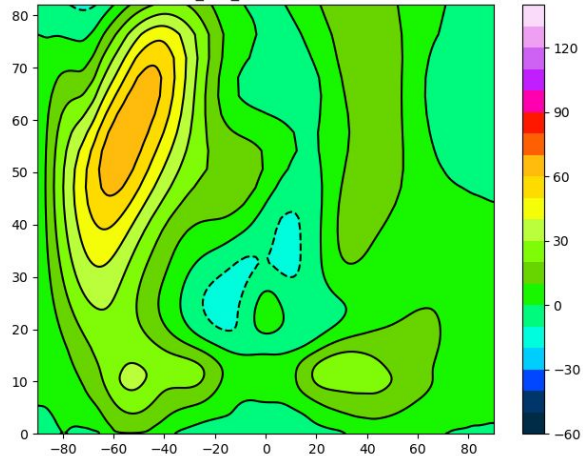
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Control <WACCM FWHIST CMIP6> MAM 1950-2014



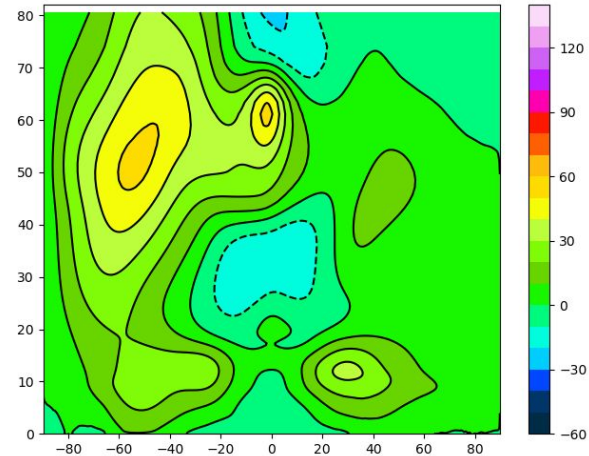
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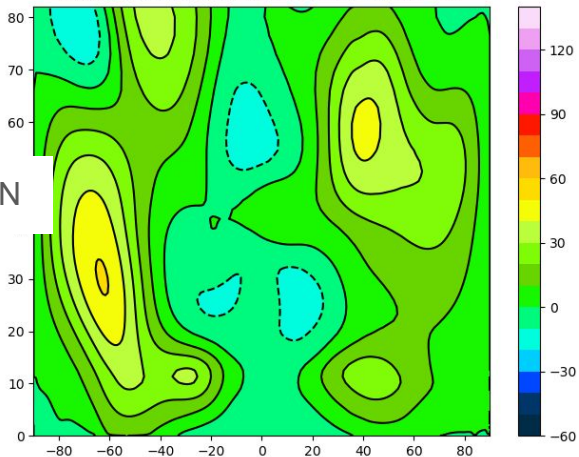


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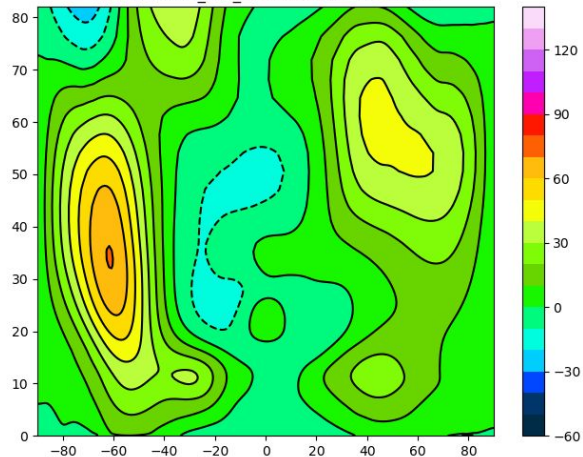
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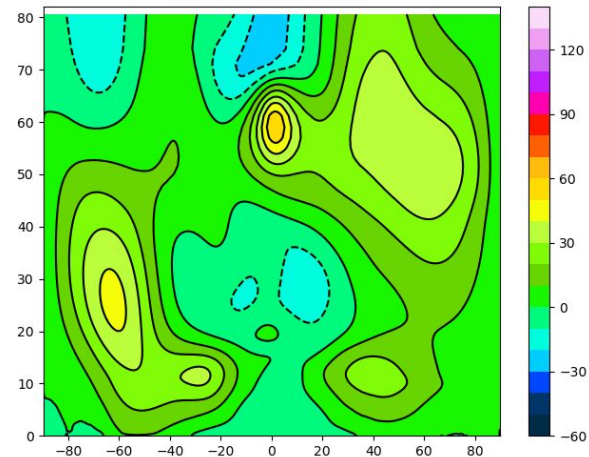
Control <WACCM FWHIST CMIP6> SON 1950-2014



Test <fmthist\_MM\_control> SON 1994-2006

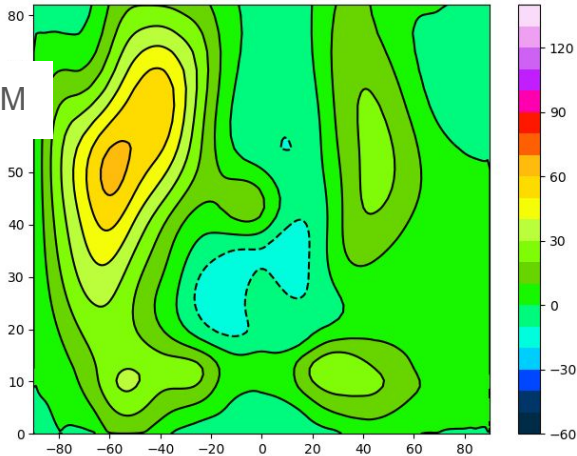


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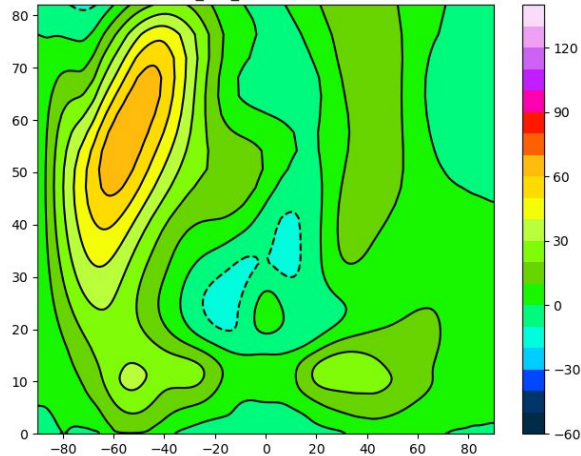
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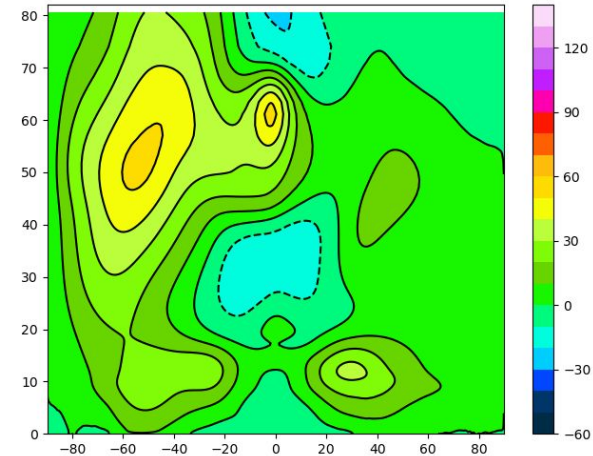
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Test <fmthist\_MM\_control> MAM 1994-2006

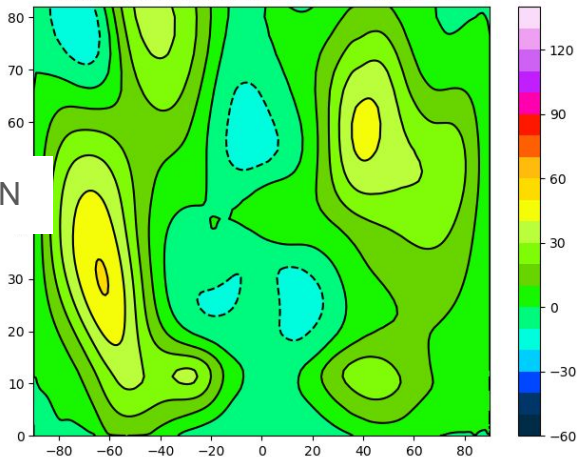


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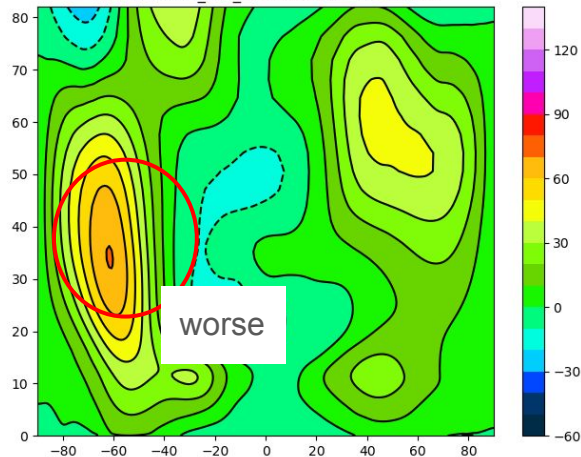
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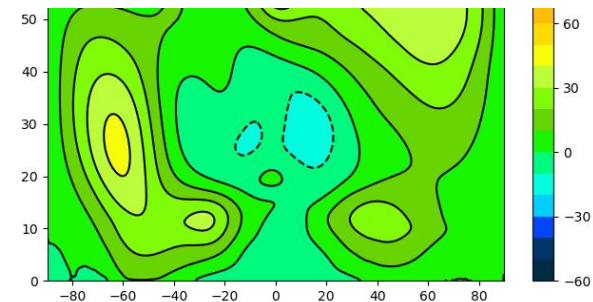
Control <WACCM FWHIST CMIP6> SON 1950-2014



Test <fmthist\_MM\_control> SON 1994-2006



- Both have delayed spring break-up in SH
- Problem for chemistry due to associated cold bias



# Speculating on why have things gotten worse in SH stratosphere

**What has changed: Dycore FV $\Rightarrow$ SE; and Vertical resolution  
~1200m $\Rightarrow$ 500m in UTLS**

- FV is more dissipative than SE, but also has higher resolution at high-latitude (i.e.  $D_x \sim 50\text{km}$  at  $60^\circ\text{N,S}$  in FV 1x1)
- Lower vertical resolution in WACCM-6 leads to more wave driving at lower altitudes

# Attempts to fix things

- Tweaking orographic gravity wave (OGW) param
  - Modest reduction in SH JJA jet strength
- Strengthening frontal GW param
  - As above + Bad effects near top (GW heating)
- Rougher topography
- Spreading wind tendencies horizontally within dycore

Nothing significantly improves late break-up. No impact on JJA “tilt”



# Do we need another GW source?

## Current GW sources

- Mountains: Only  $c=0$ . Limited leverage in SH.
- Deep convection: Broad c-spectrum. Driven by ZM heating
- Fronts: Broad c-spectrum. Prescribed flux in diagnosed fronts.

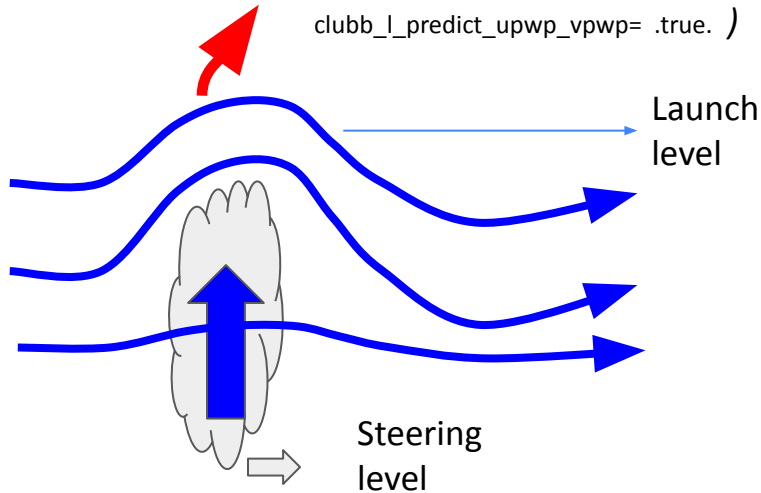
# Initial tests - Moving mountains from PBL work with **Martina Bramberger, Joan Alexander (CoRA)**

Talk by Martina tomorrow 1:30

## Missing GW source?

- Moving Mountains: Low but non-zero phase speeds

Launch level momentum flux (*currently estimated from CLUBB mom fluxes*  
`clubb_l_predict_upwp_vpwp= .true. )`



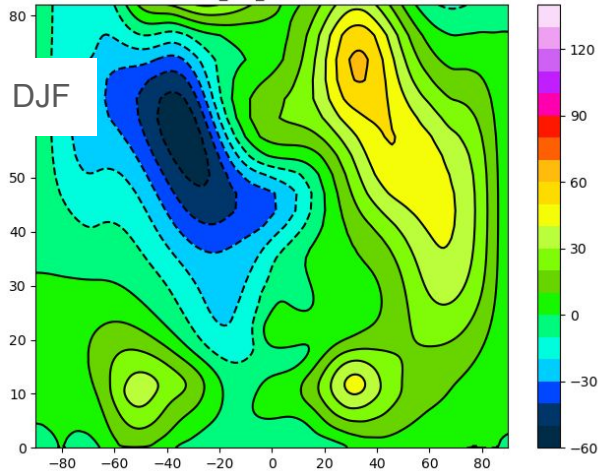
## Test #1:

- Steering level fixed to ~40m
- Launch level fixed to ~750m
- Source momentum flux:
  - 0.01 x average CLUBB momentum flux 0-750m



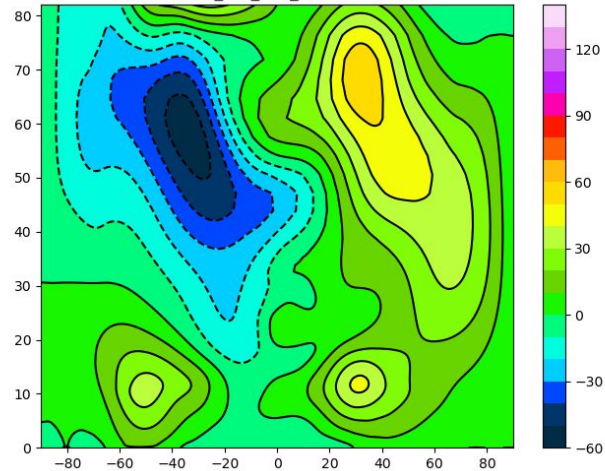
# CAM7 FMTHIST L93 Control

Control <fmthist\_MM\_control> DJF 1994-2006



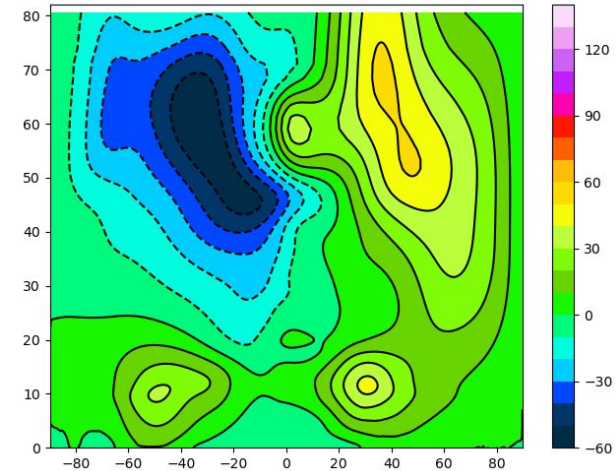
# CAM7 FMTHIST+moving mtn

Test <fmthist\_MM\_x21\_2> DJF 1994-2005

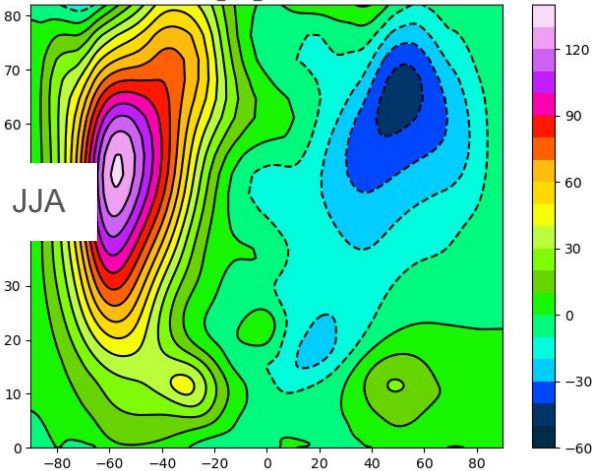


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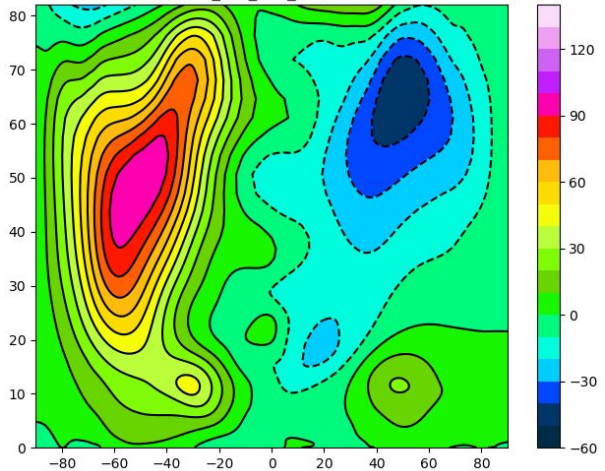
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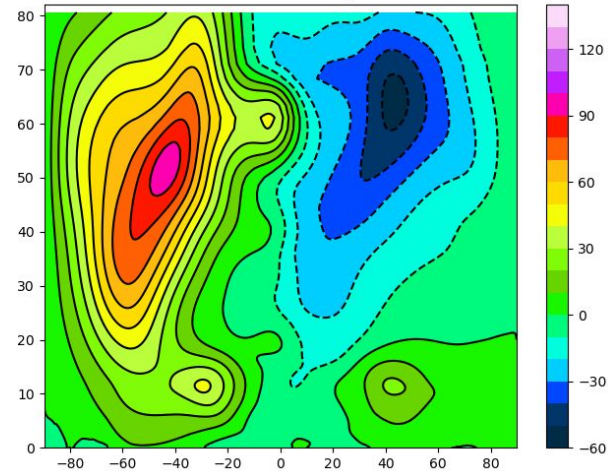
Control <fmthist\_MM\_control> JJA 1994-2006



Test <fmthist\_MM\_x21\_2> JJA 1994-2005

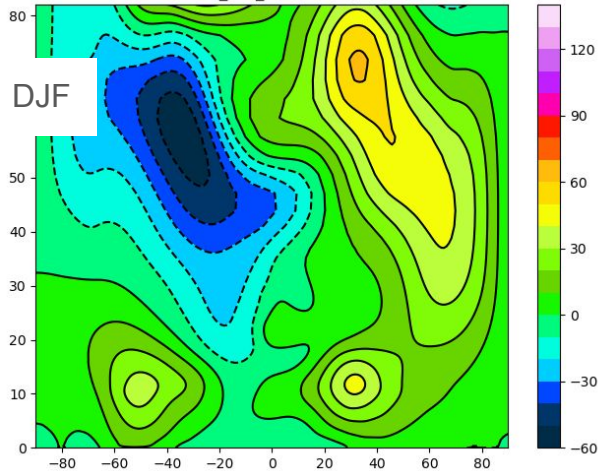


Validation <ERA-5> JJA



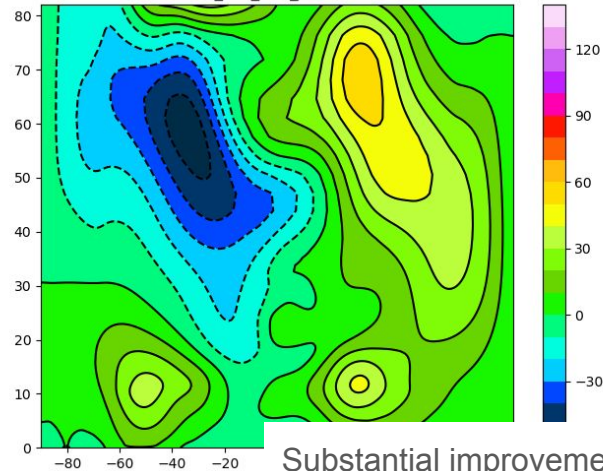
# CAM7 FMTHIST L93 Control

Control <fmthist\_MM\_control> DJF 1994-2006



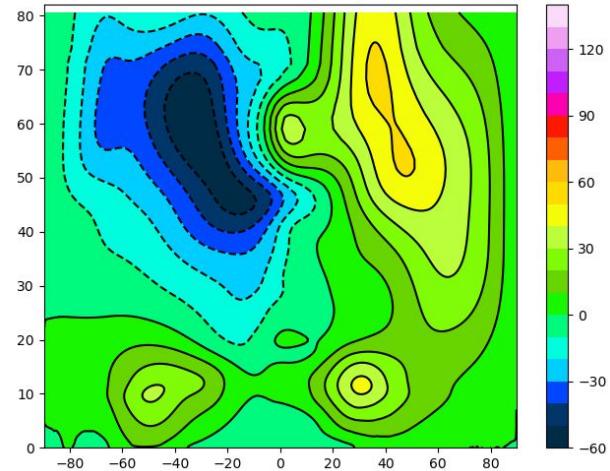
# CAM7 FMTHIST+moving mtn

Test <fmthist\_MM\_x21\_2> DJF 1994-2005



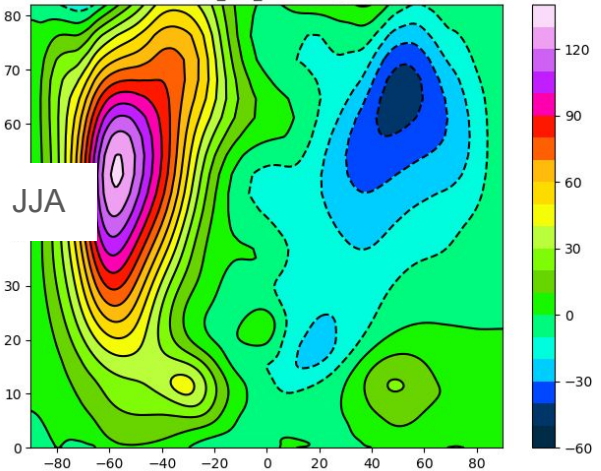
# ERA5

Validation <ERA-5> DJF

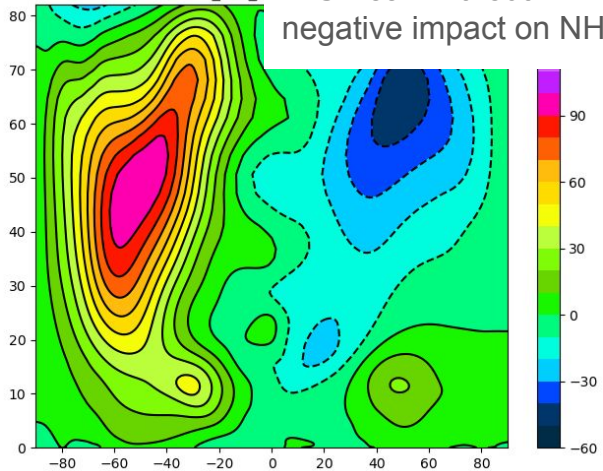


Substantial improvement  
in SH JJA without  
negative impact on NH

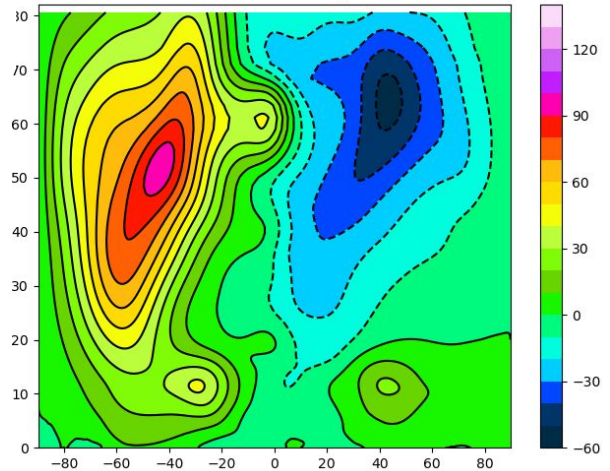
Control <fmthist\_MM\_control> JJA 1994-2006



Test <fmthist\_MM\_x

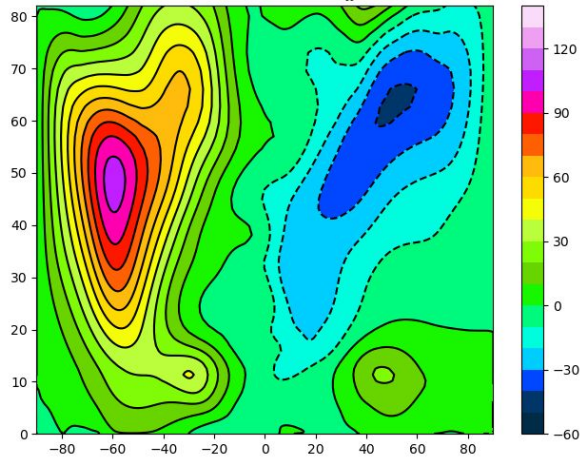


Validation <ERA-5> JJA



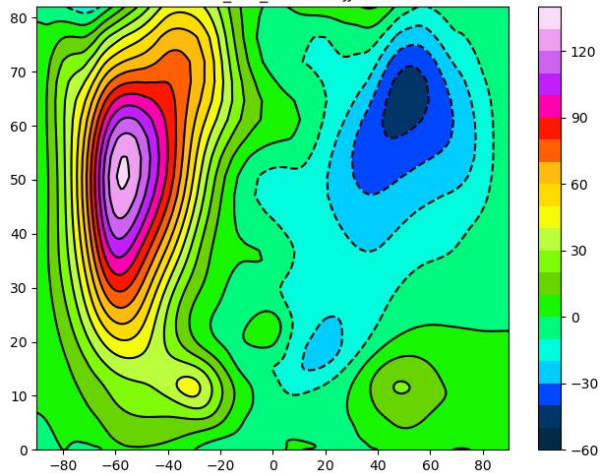
# WACCM6 FWHIST L72

Control <WACCM FWHIST CMIP6> JJA 1950-2014



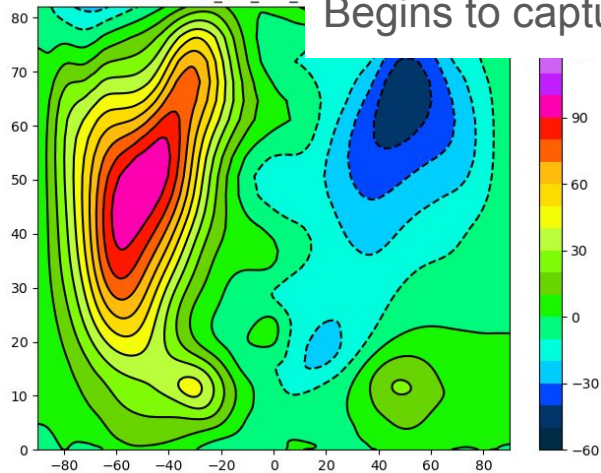
# CAM7 FMTHIST L93 Control

Control <fmthist\_MM\_control> JJA 1994-2006



# CAM7 FMTHIST L93 Test

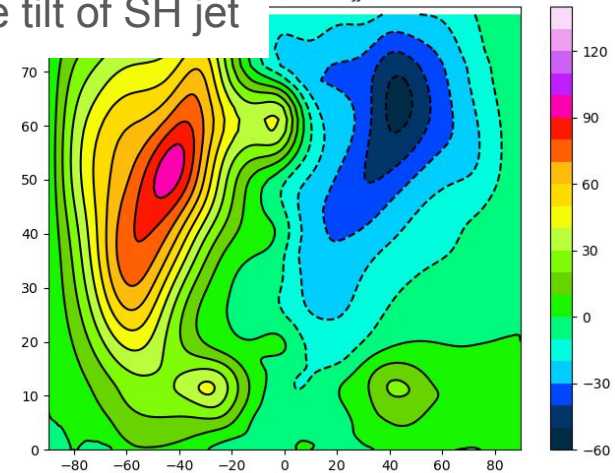
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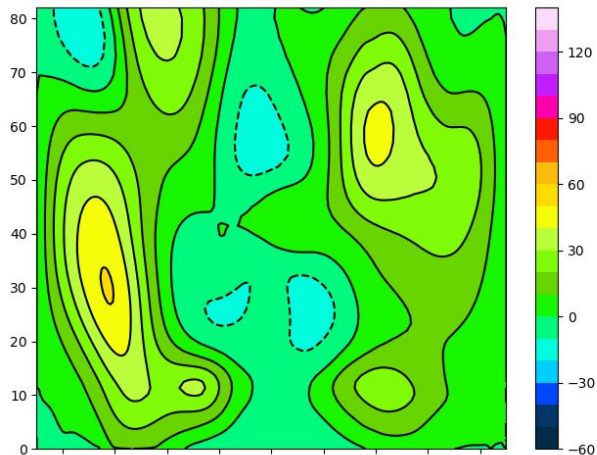
Begins to capture tilt of SH jet

# ERA5

<ERA-5> JJA

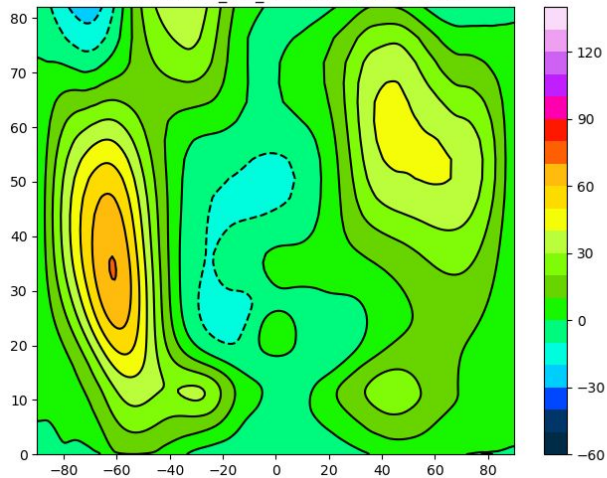


Control <WACCM FWHIST CMIP6> SON 1950-2014

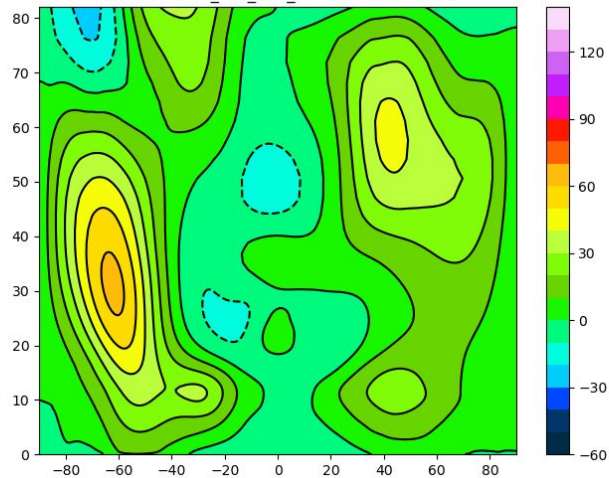


Spring transition improved but still delayed - more than in WACCM6

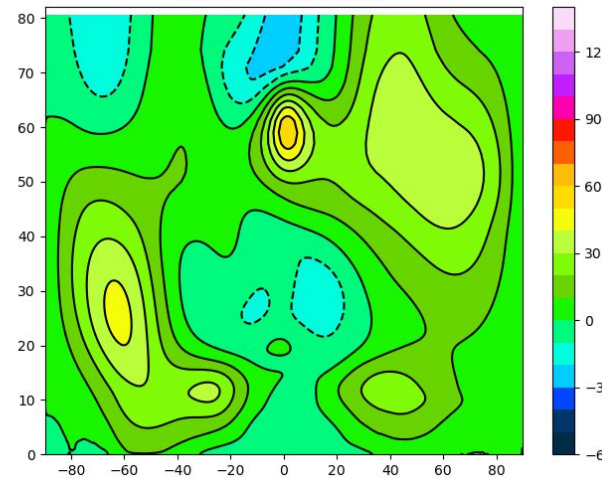
Control <fmthist\_MM\_control> SON 1994-2006



Test <fmthist\_MM\_x21\_2> SON 1994-2005



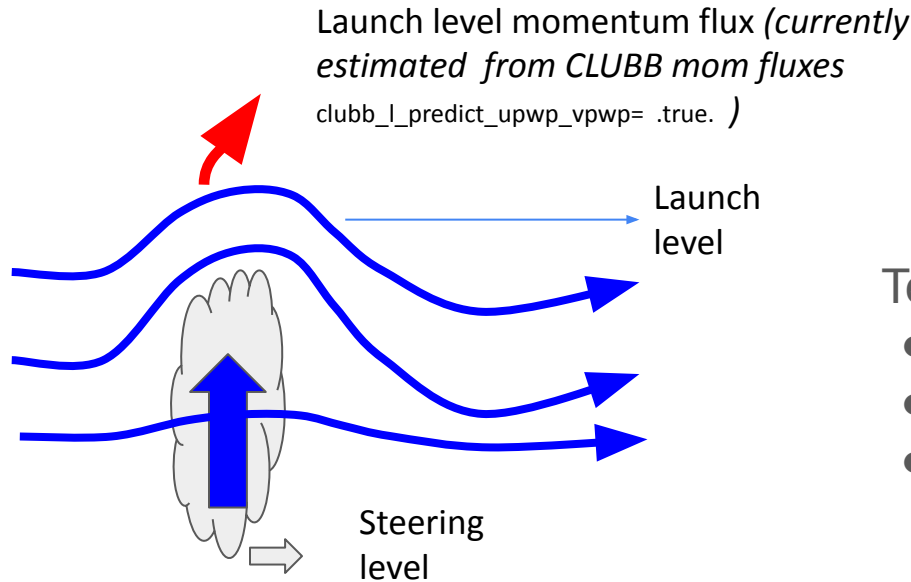
Validation <ERA-5> SON



# Initial tests - Moving mountains from PBL work with **Martina Bramberger, Joan Alexander (CoRA)**

## Missing GW source?

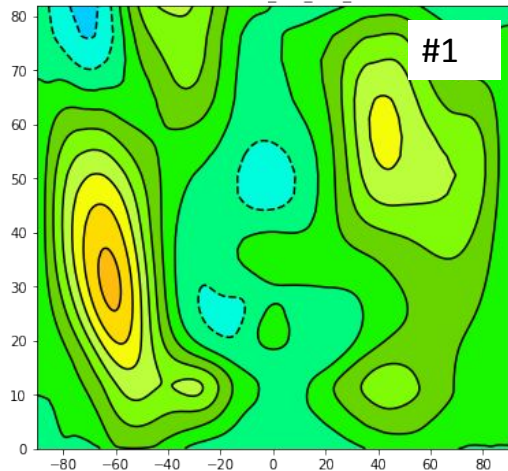
- Moving Mountains: Low but non-zero phase speeds



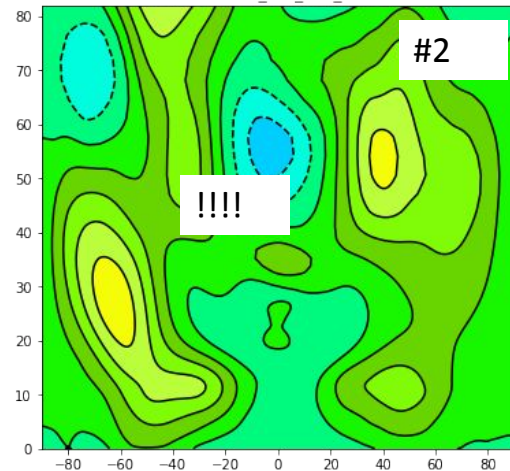
## Test #2:

- Steering level fixed to ~40m
- Launch level fixed to ~750m
- Source momentum flux:
  - **0.05** x average CLUBB momentum flux 0-750m

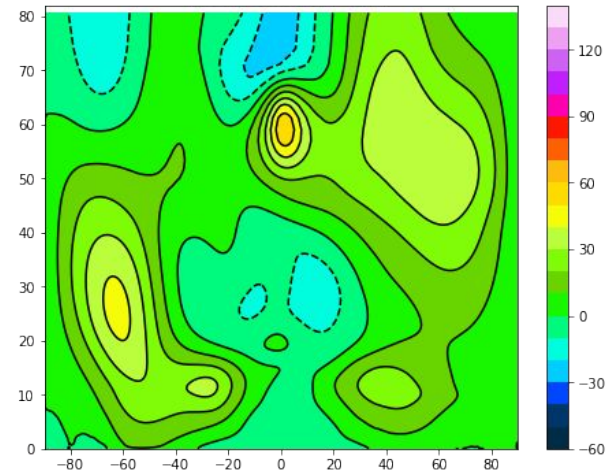
Control &lt;fmthist\_MM\_x21\_2&gt; SON



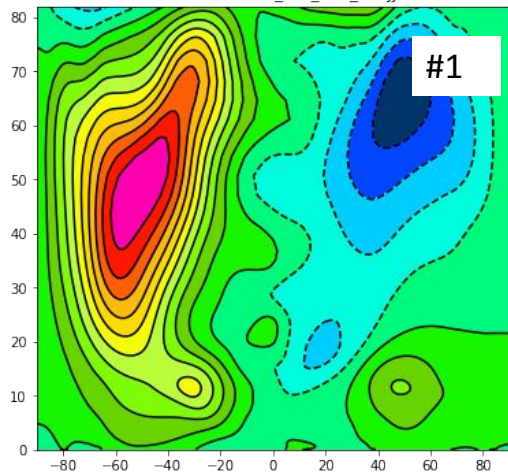
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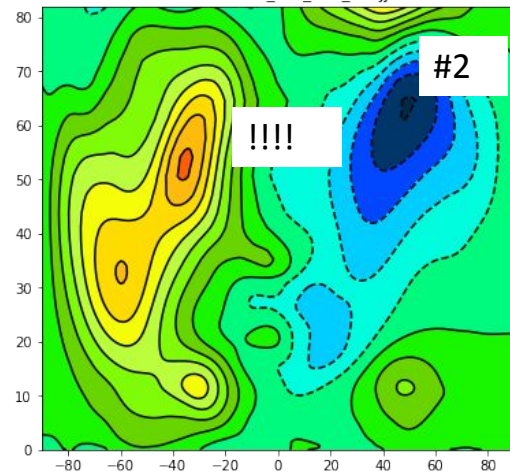
Validation &lt;ERA-5&gt; SON



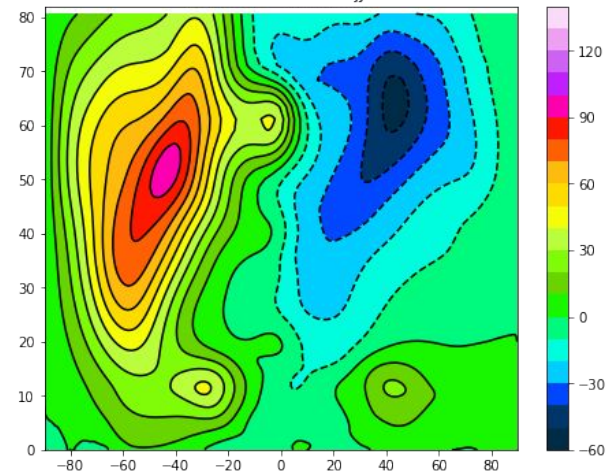
Control &lt;fmthist\_MM\_x21\_2&gt; JJA



Test &lt;fmthist\_MM\_x21\_3&gt; JJA



Validation &lt;ERA-5&gt; JJA





## Summary

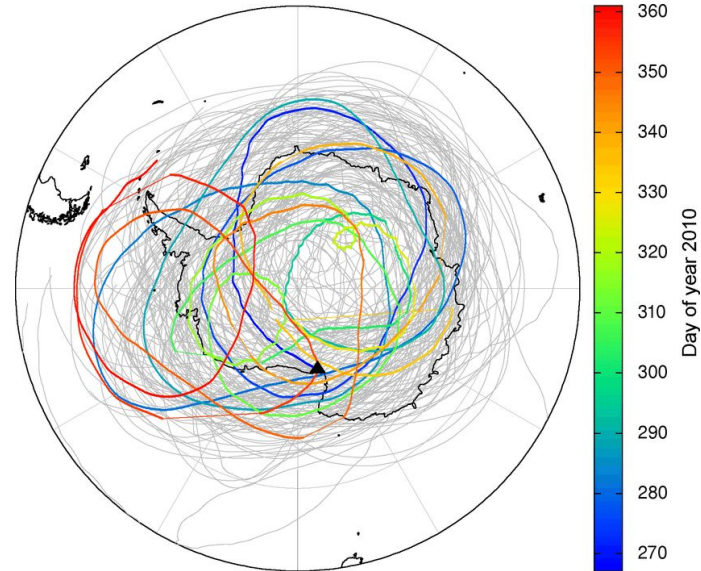
- PBL-based moving-mountain source shows promise towards solving long standing SH stratospheric wind biases
- Source may need some work
- *More tomorrow 1:30*

## Caveat

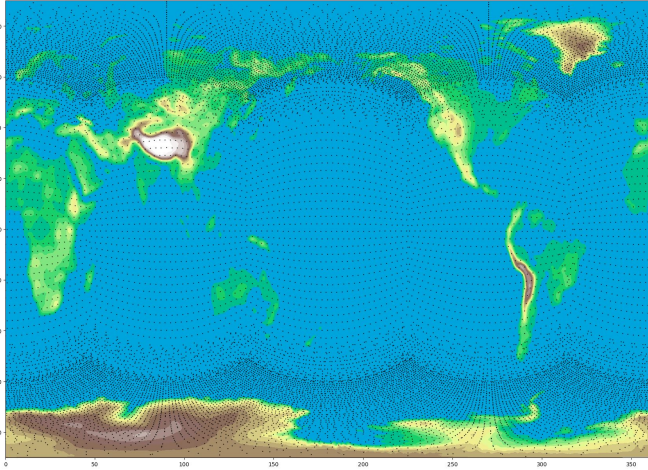
- Analysis of nudging runs (to ERA5) doesn't show good correspondence between large stratospheric nudging tendencies in control and moving mtn GW tendencies

# Moving mountains from PBL: future work

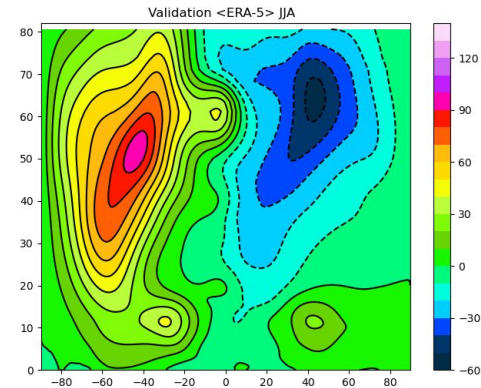
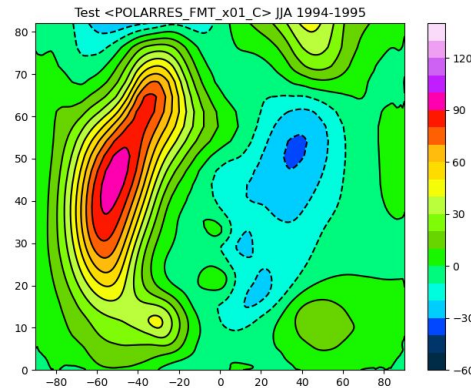
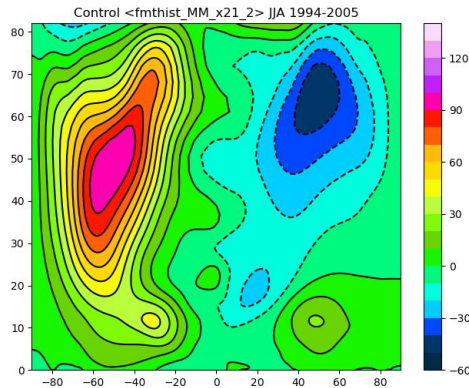
- More work needed to understand nudging tendencies
- Nudging analysis against balloon data from 2010?
  - Balloons can measure  $u'w'$   $v'w'$  directly
- Better formulated source



# Moving mountains from PBL: future work



- Dual Polar grid (A. Herrington, R. Wijngaard) 100km global  $\Rightarrow$  25km polar



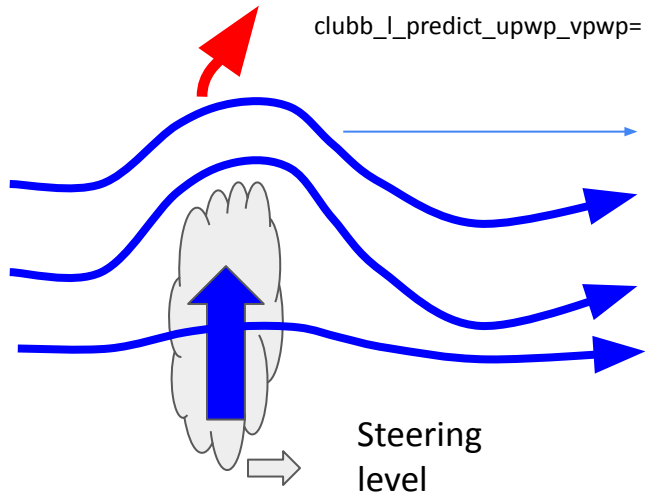
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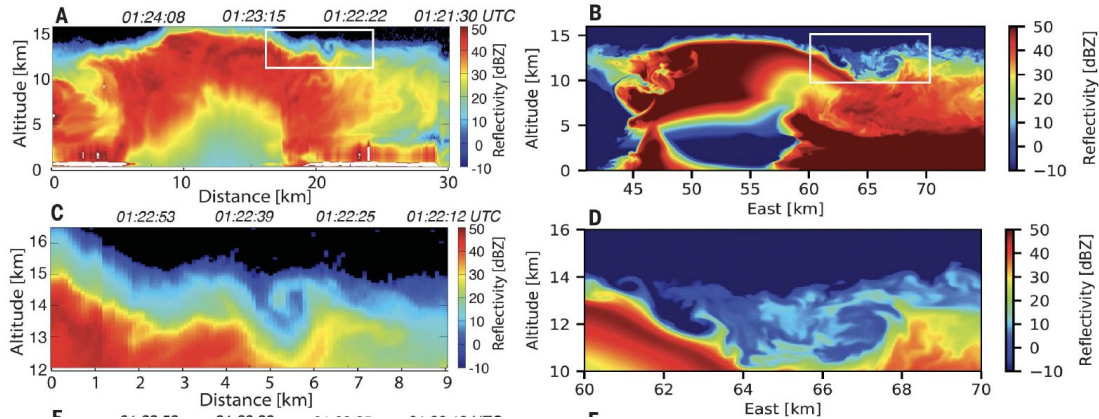
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Hydraulic jump dynamics above supercell thunderstorms  
Morgan E O'Neill, Leigh Orf, Gerald M. Heymsfield, and Kelton Halbert

Science, 373 (6560), .  
DOI: 10.1126/science.abh3857



Thank you