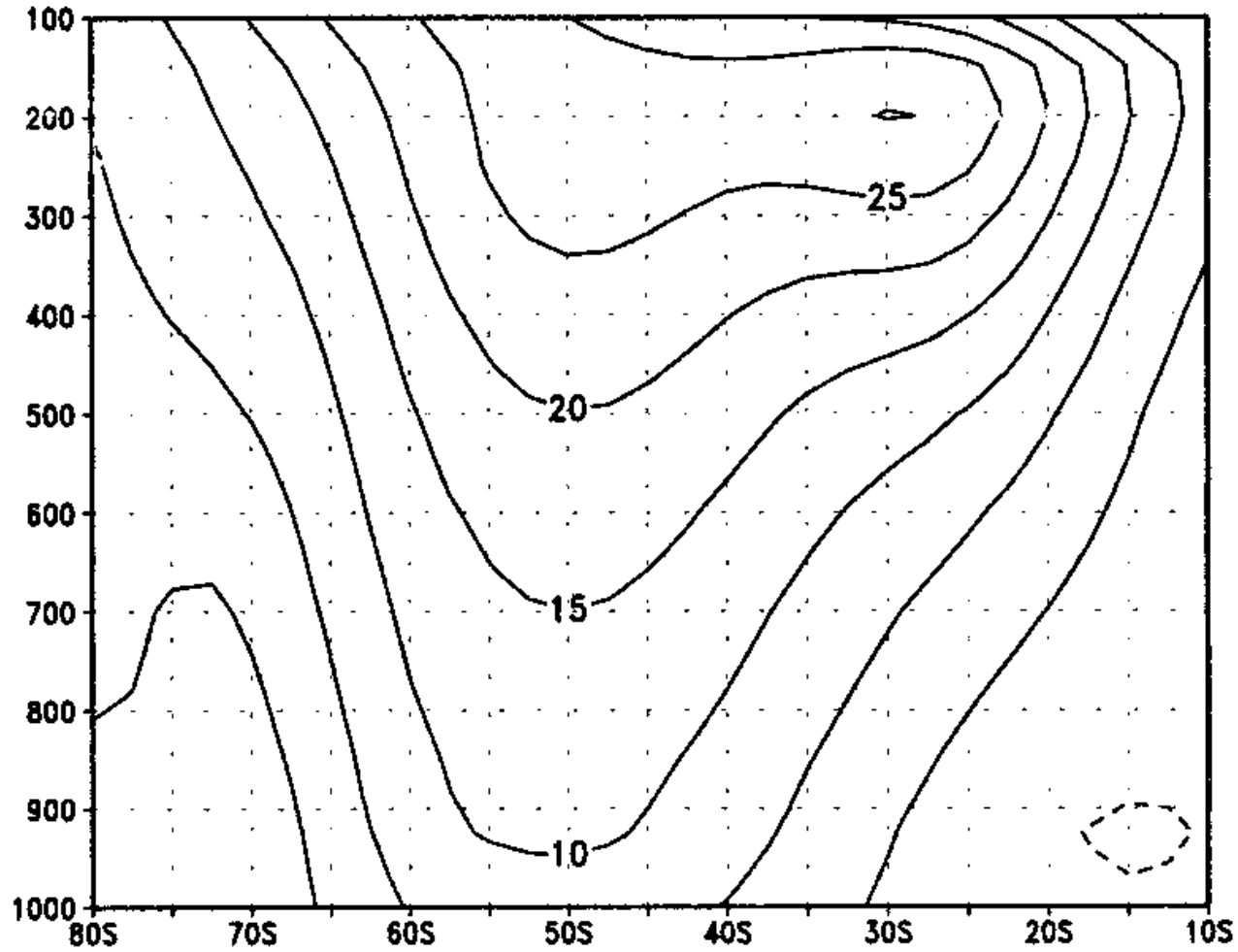


# The role of tropospheric dynamics in stratosphere/troposphere coupling

Dave Thompson, CSU

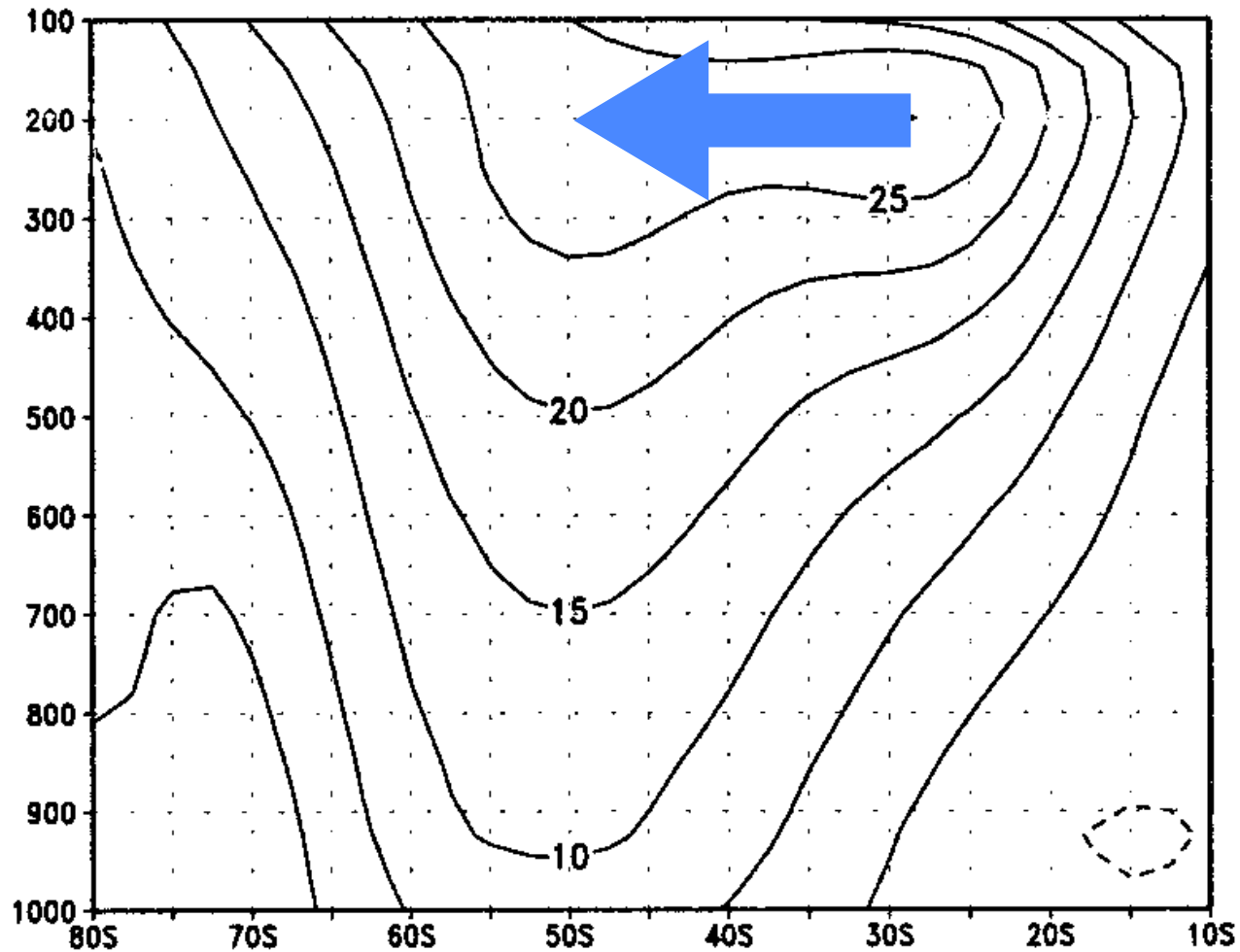
# SH annual mean zonal mean zonal wind

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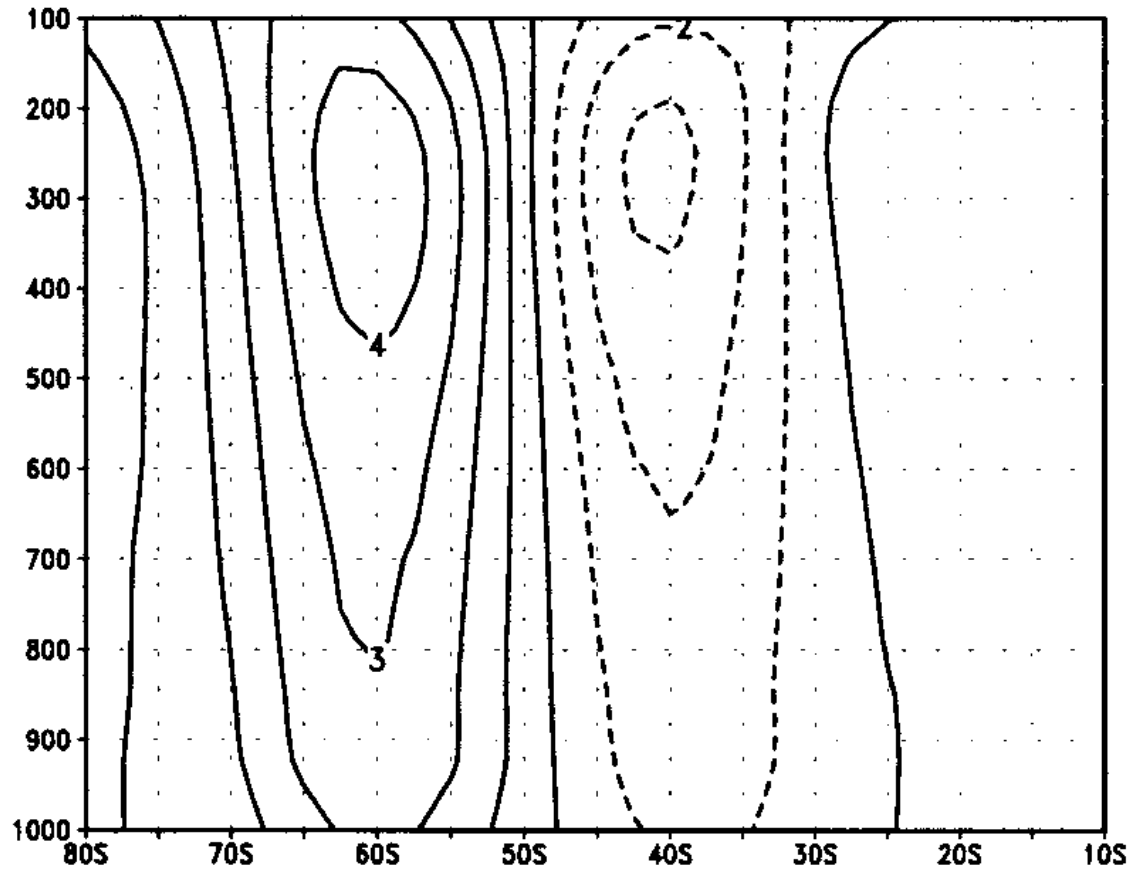
# SH annual mean zonal mean zonal wind

flux of zonal momentum by eddies



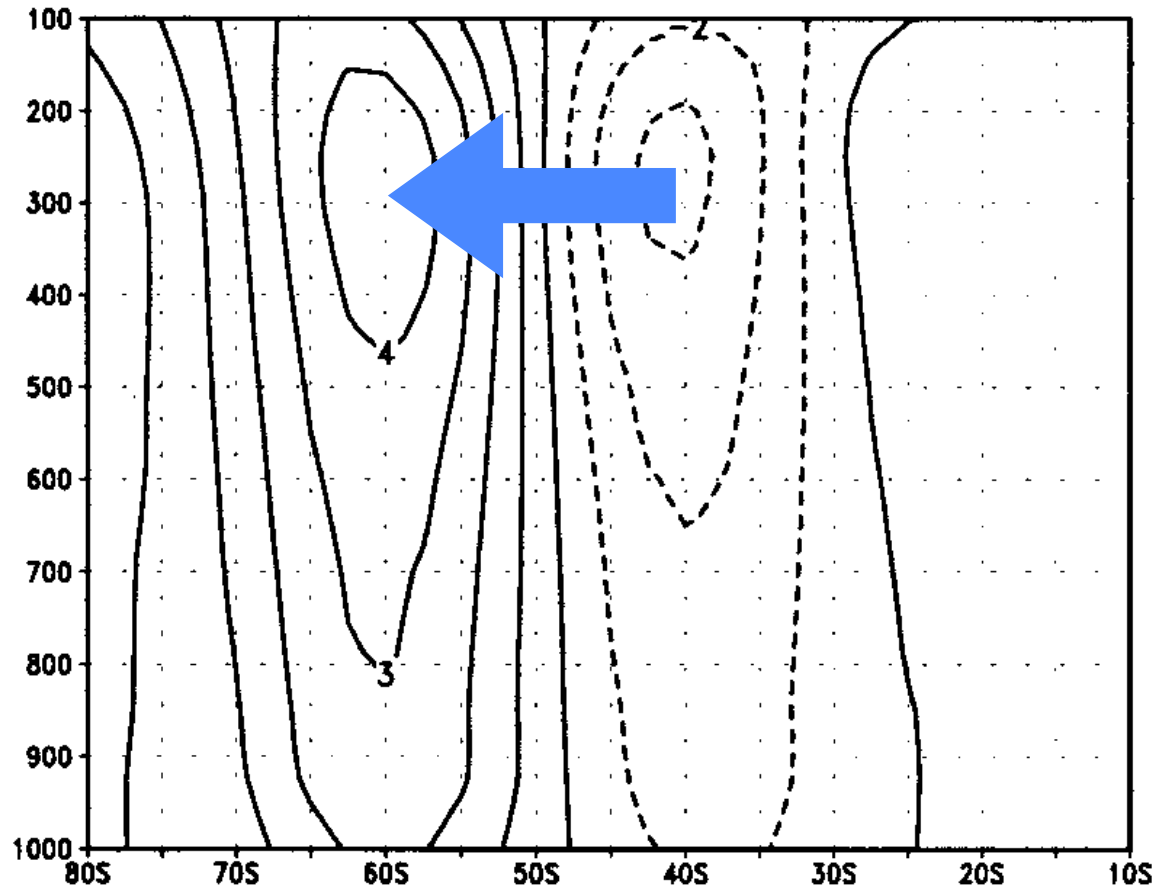
# [U] regressed on SH annular mode

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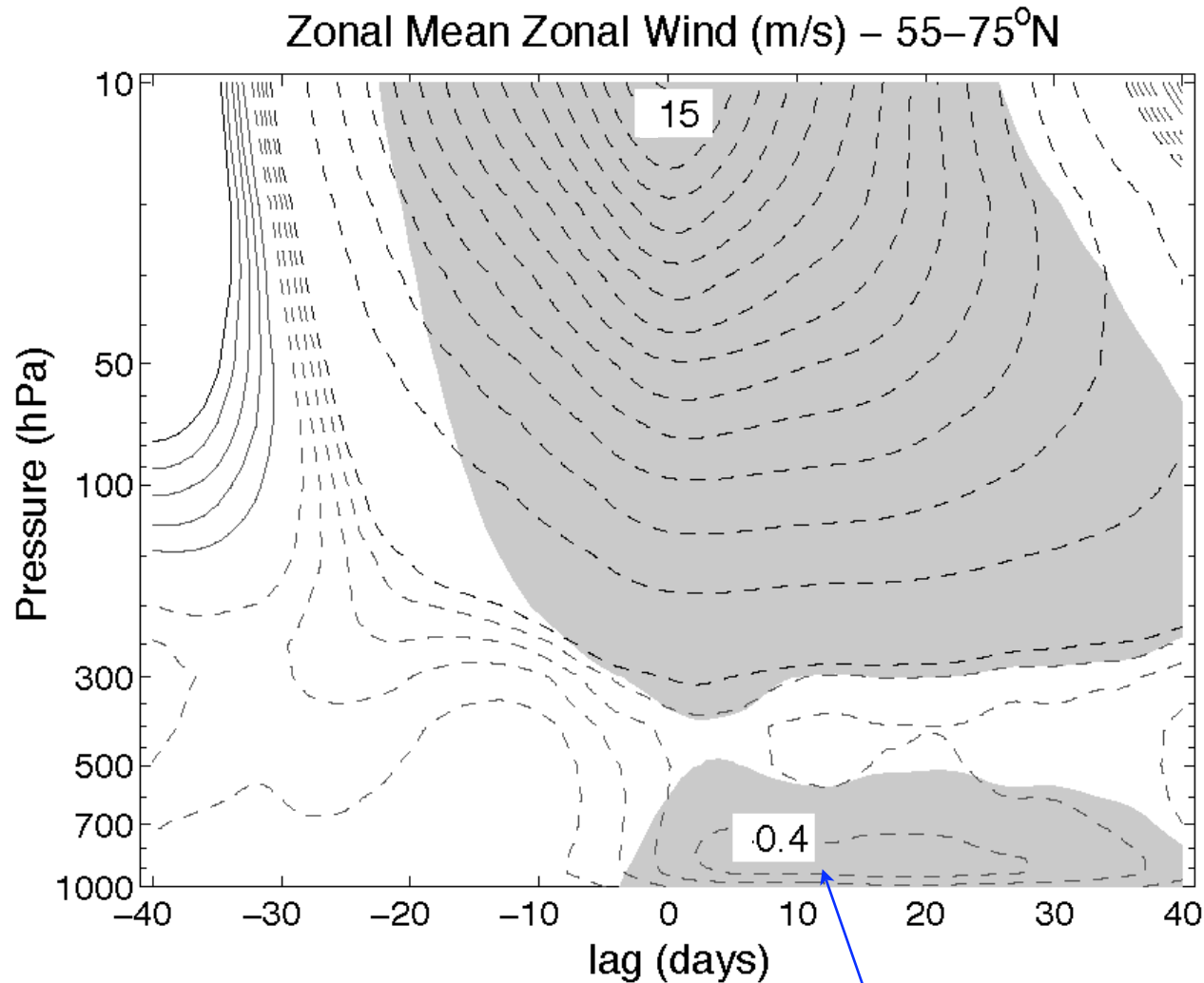
# [U] regressed on SH annular mode

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*the climatology and variability of the tropospheric flow are both strongly dependent on the momentum fluxes*

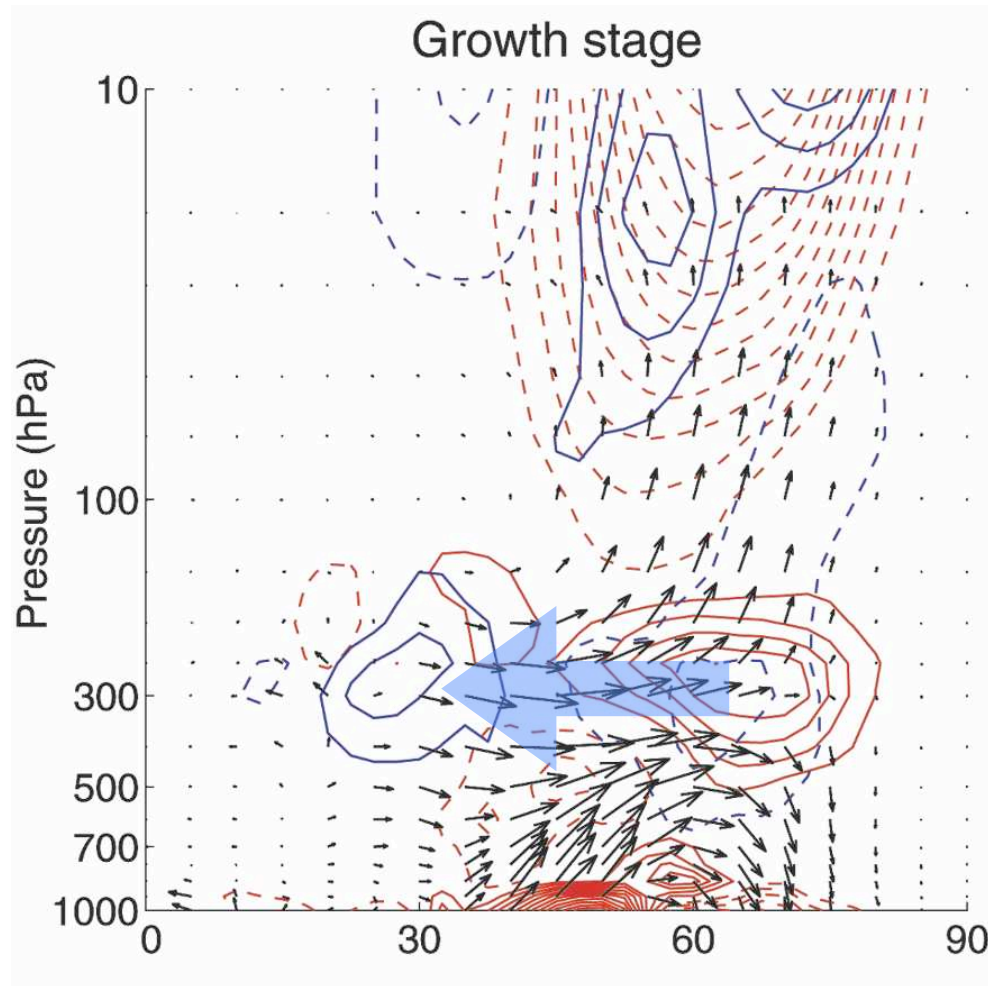
# Regressions on NAM at 10 hPa



*timescale suggests stratospheric influence*

*eg Baldwin and Dunkerton 2001*

# EP fluxes regressed on NAM at 10 hPa



*the tropospheric response to stratospheric variability is also strongly dependent on the momentum fluxes.*

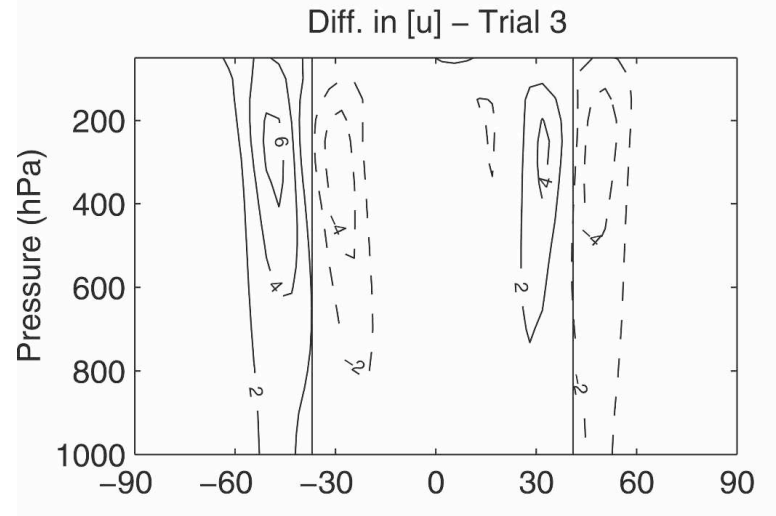
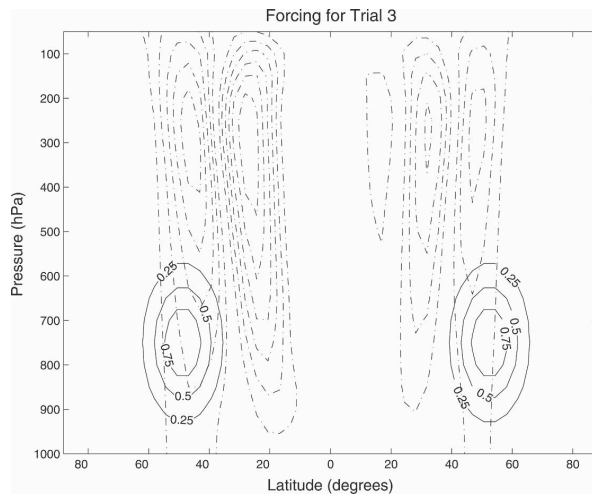
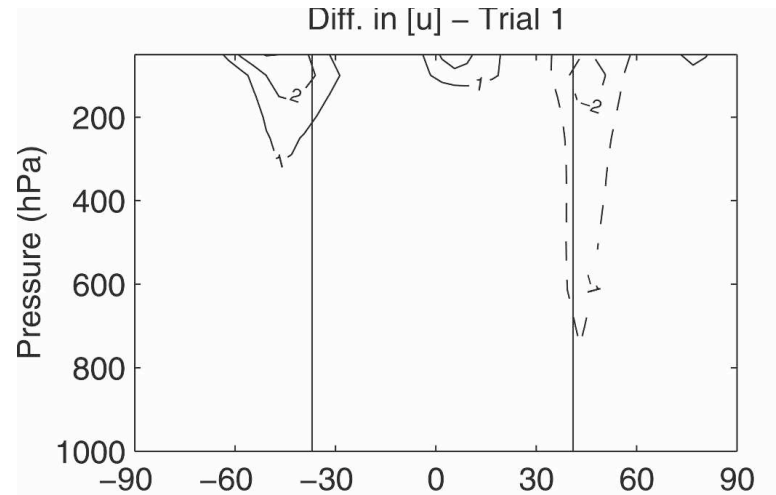
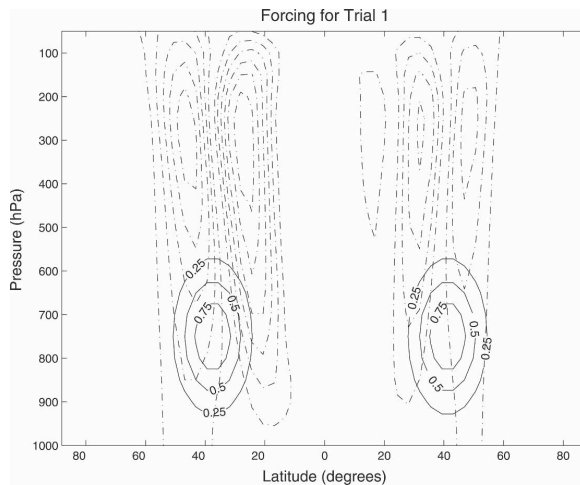
*from Thompson, Furtado, Shepherd 2006*

the problem...

- it's clear how the momentum fluxes impact the wind and temperature fields
- it's less clear how the wind and temperature fields impact the momentum fluxes



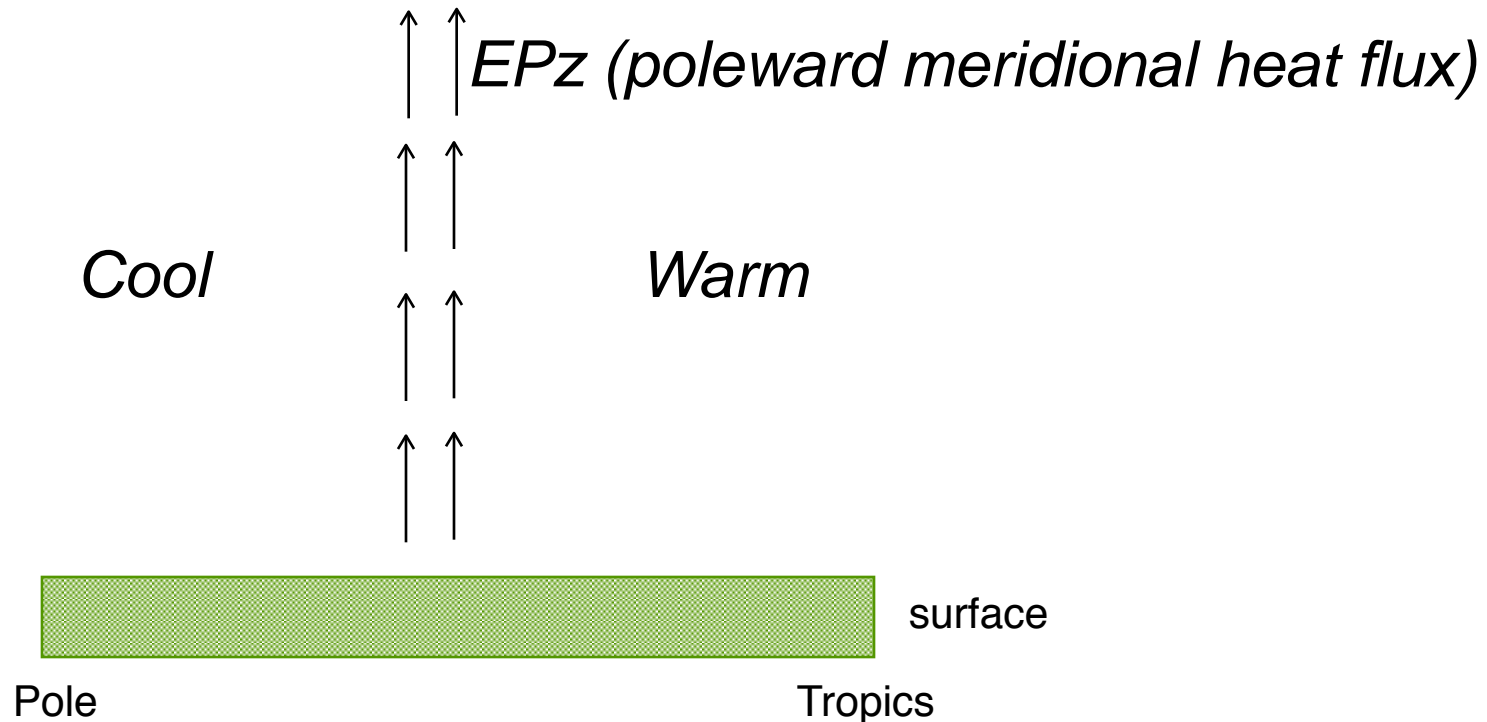
*we know such feedbacks exist....*



*Ring and Plumb 2007*

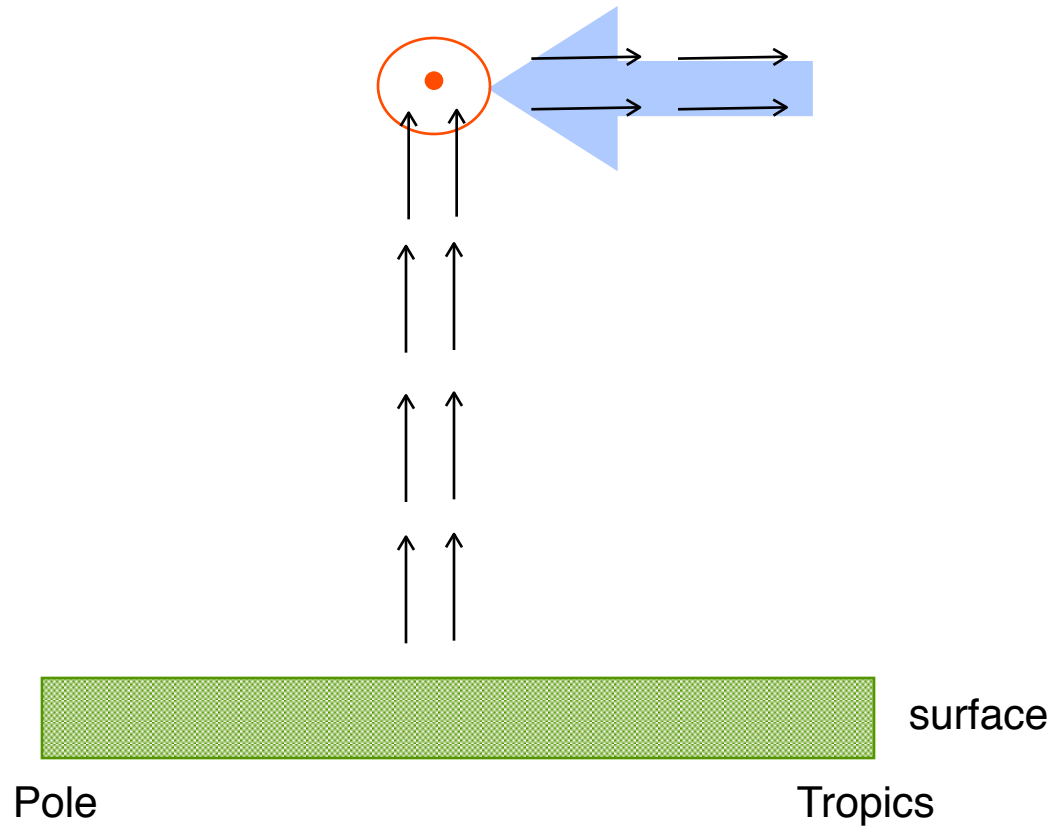
*but we re not sure exactly how such feedbacks operate.  
one possibility:*

*changes in lower tropospheric baroclinicity*



*Robinson 2000; Lorenz and Hartmann 2001*

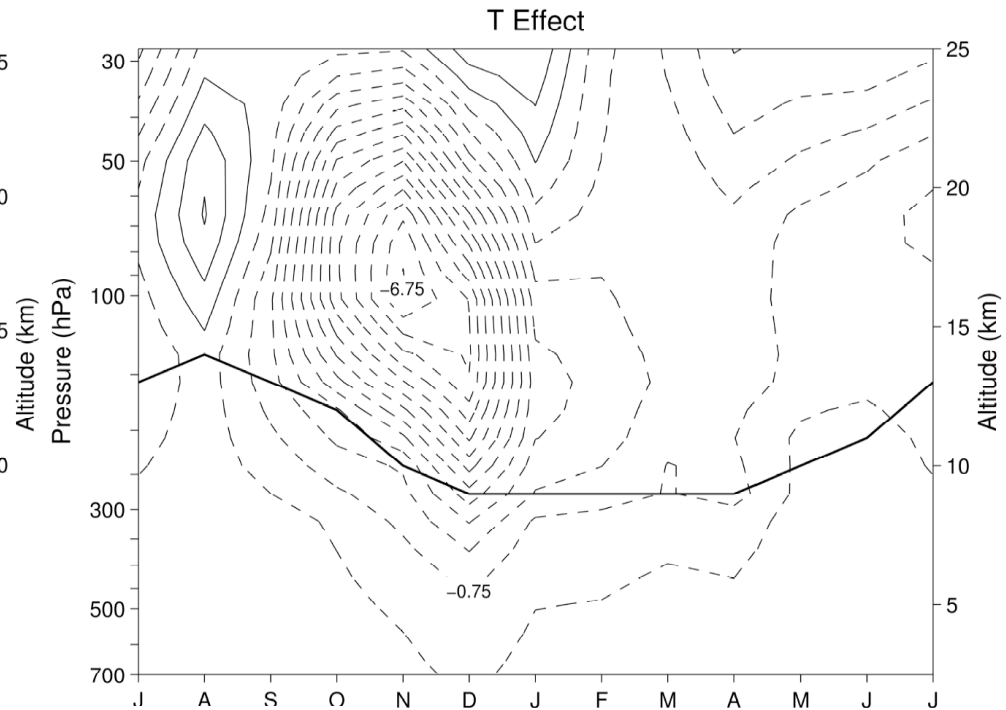
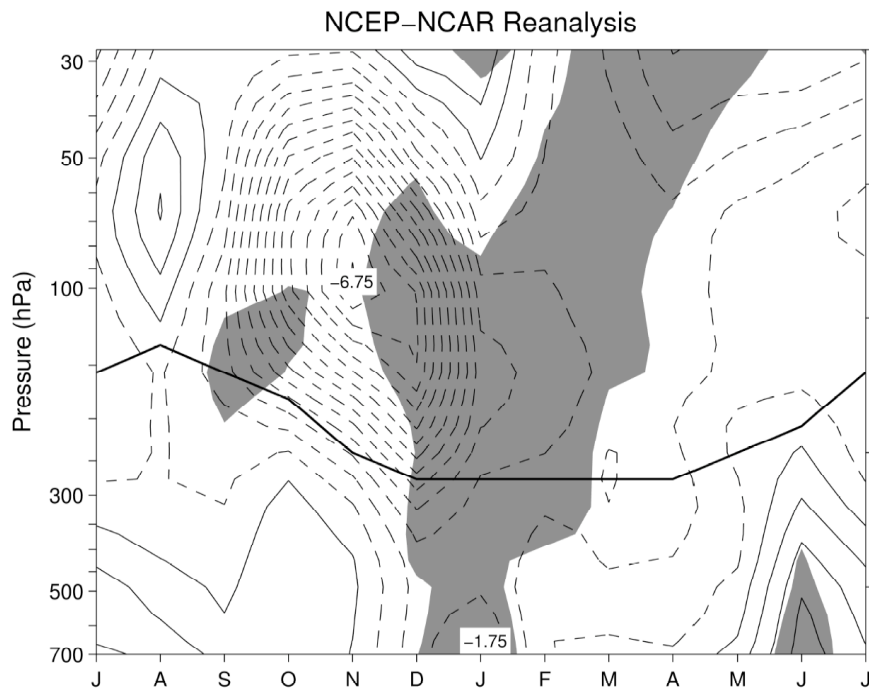
*waves propagate meridionally in upper troposphere;  
momentum flux converges in stirring region*



# how does this relate to stratosphere/troposphere coupling?

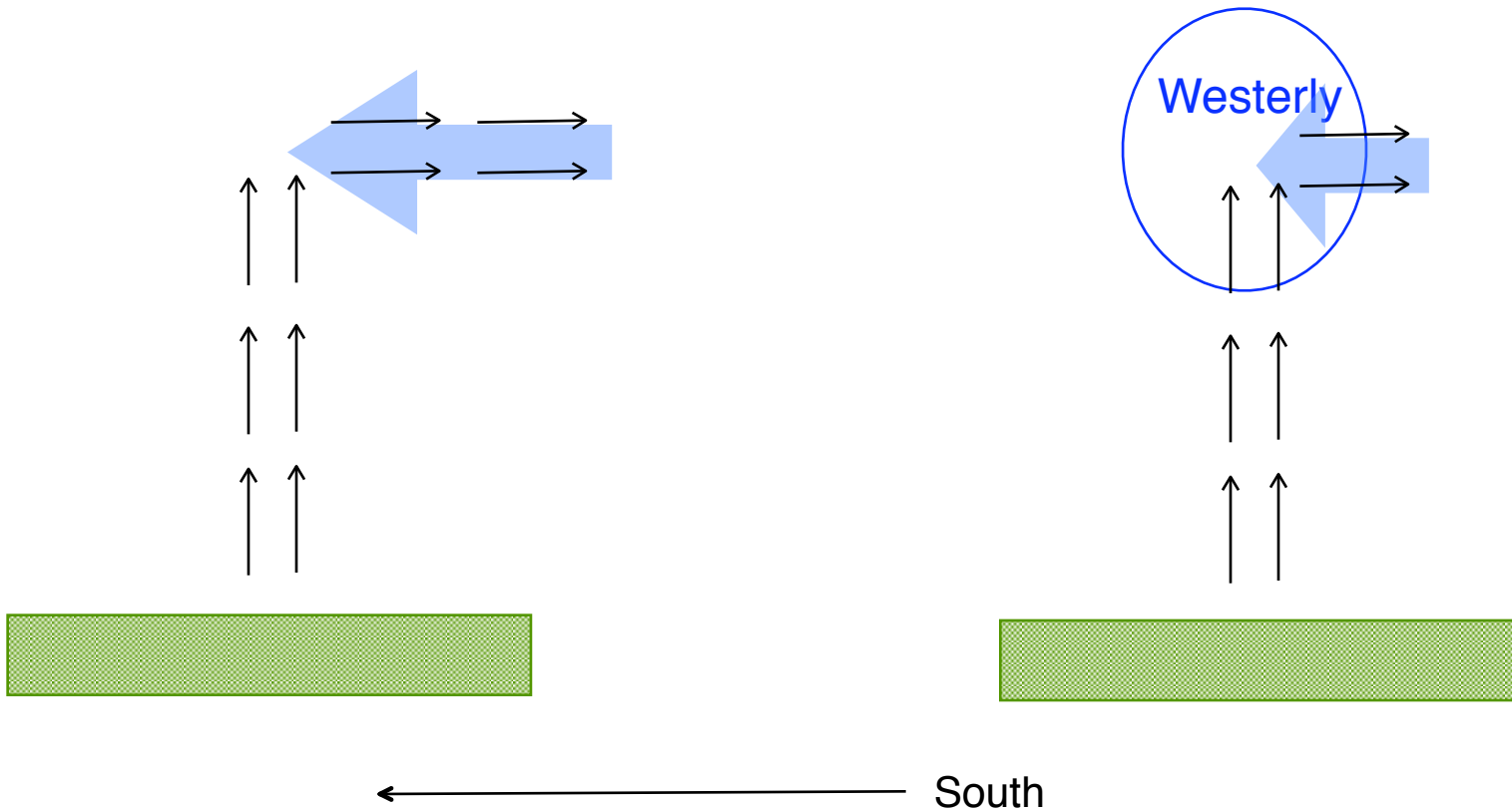
a) burrowing meridional circulation: DCWEF (Robinson 2006)

b) longwave radiative fluxes from stratosphere (Grise/Thompson/Forster 2008)



## *a second possibility:*

*increased [U] -> higher Cph -> waves break farther poleward*

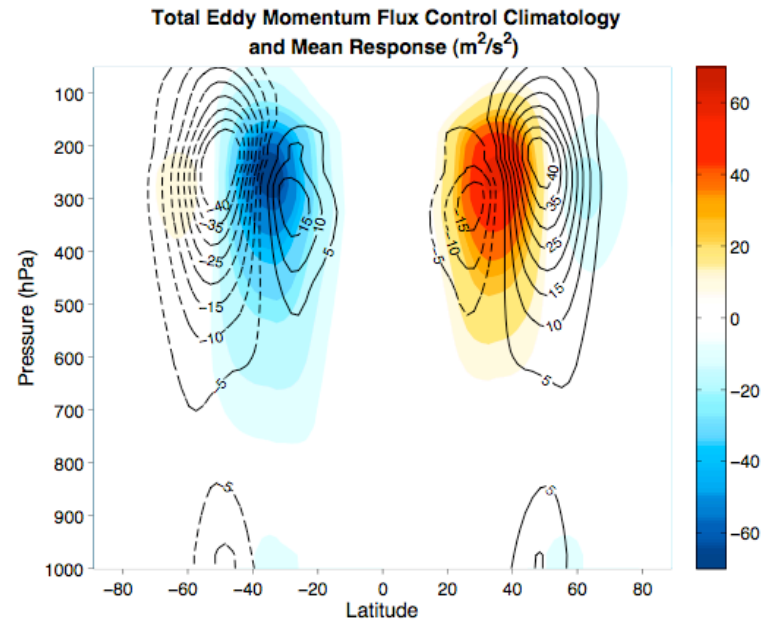
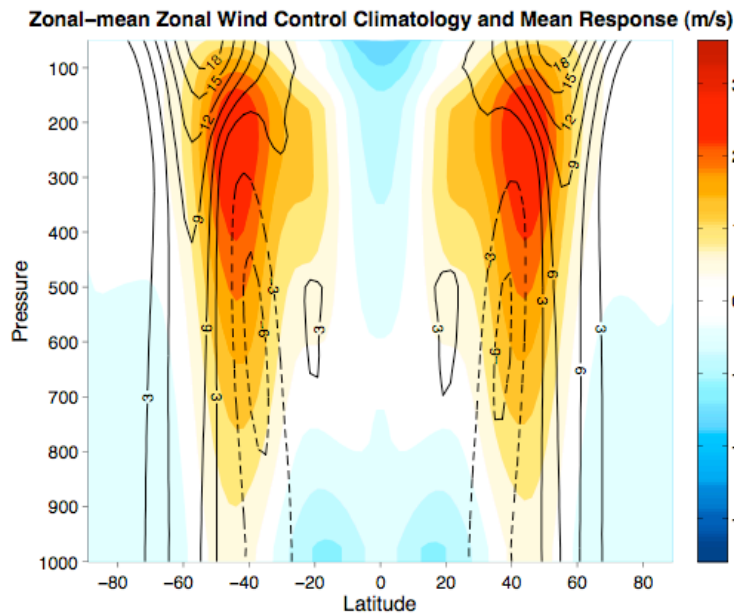
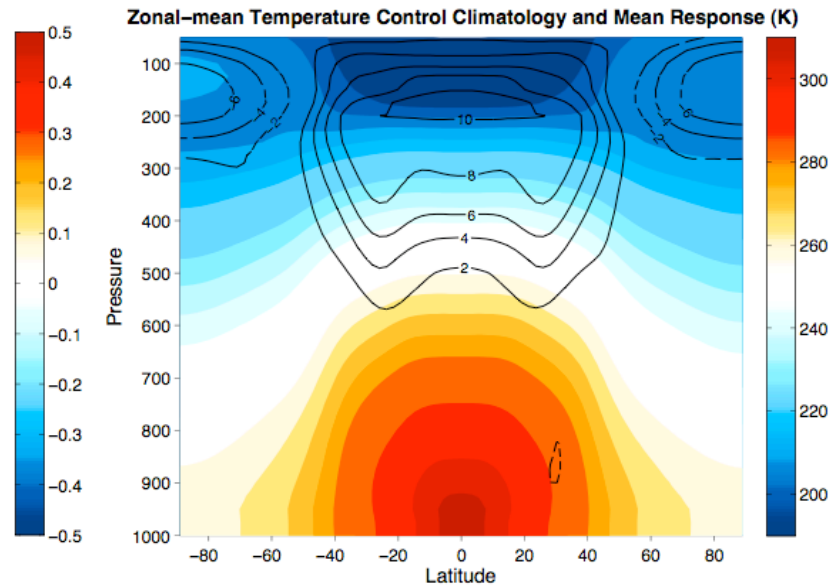
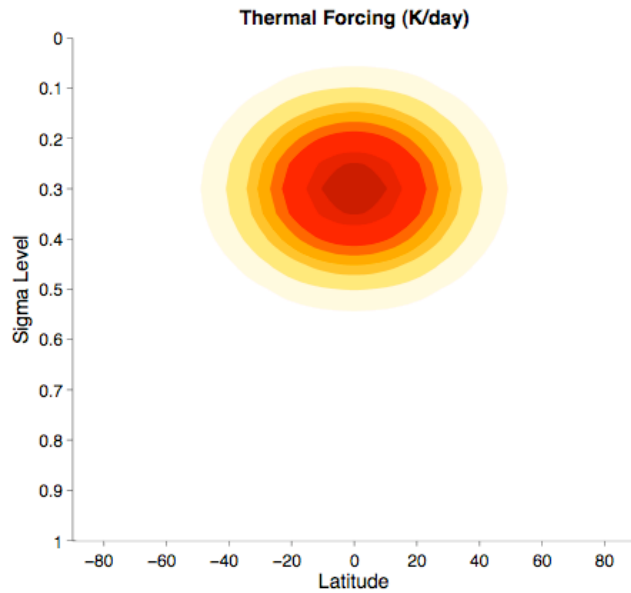


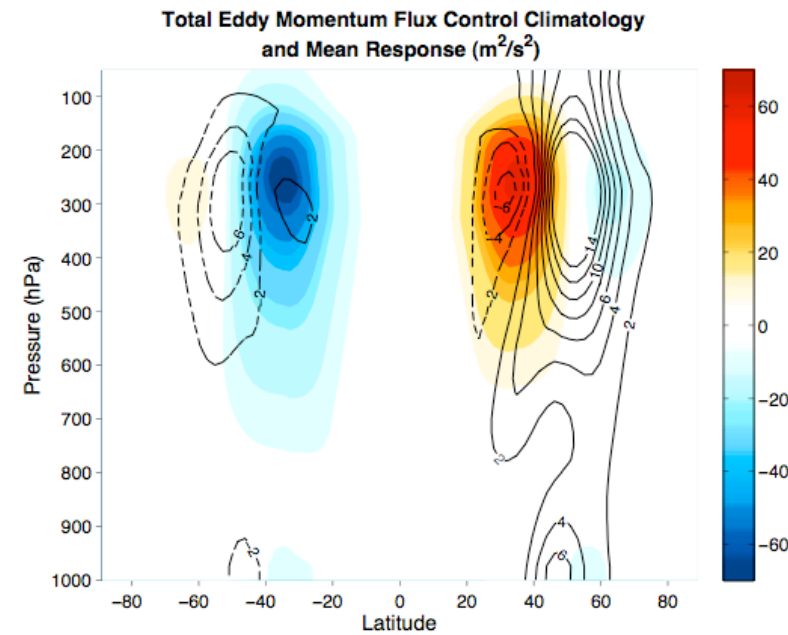
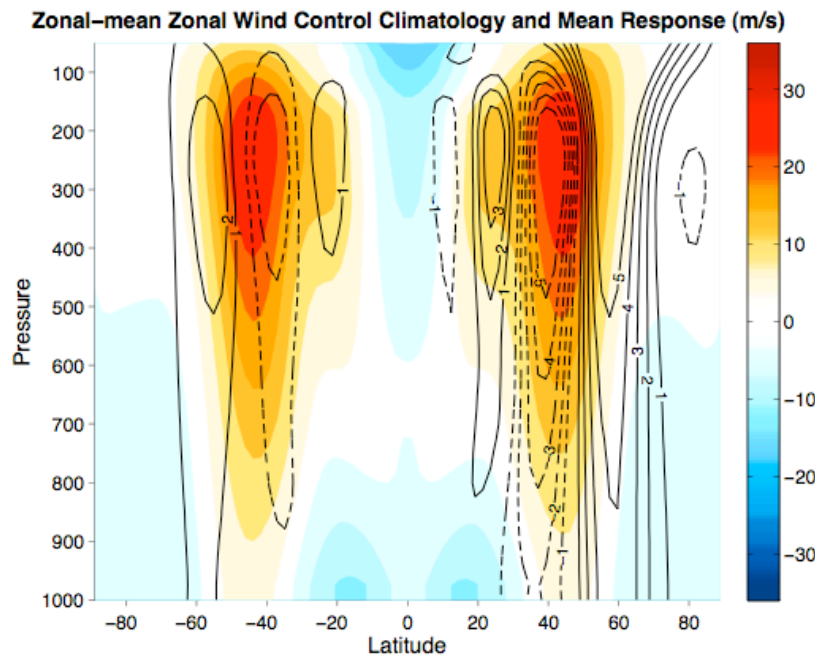
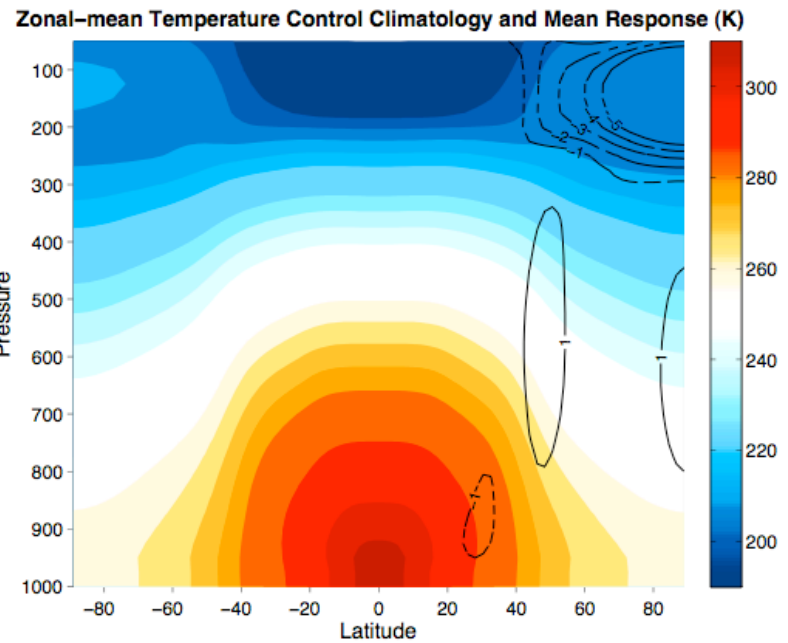
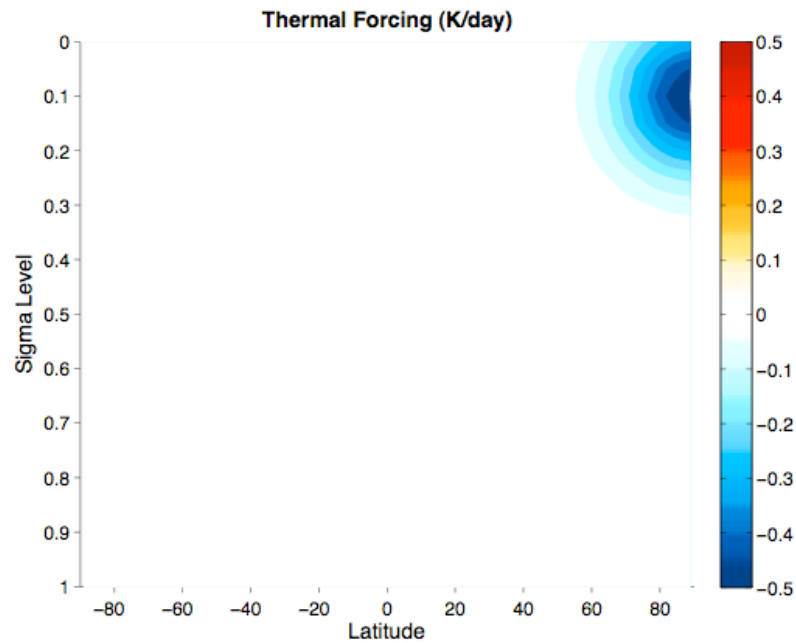
*Chen and Held (2007; see also Wittman et al. 2007)*

*understanding the eddy response to changes in the mean flow is key for understanding stratosphere/troposphere coupling.*

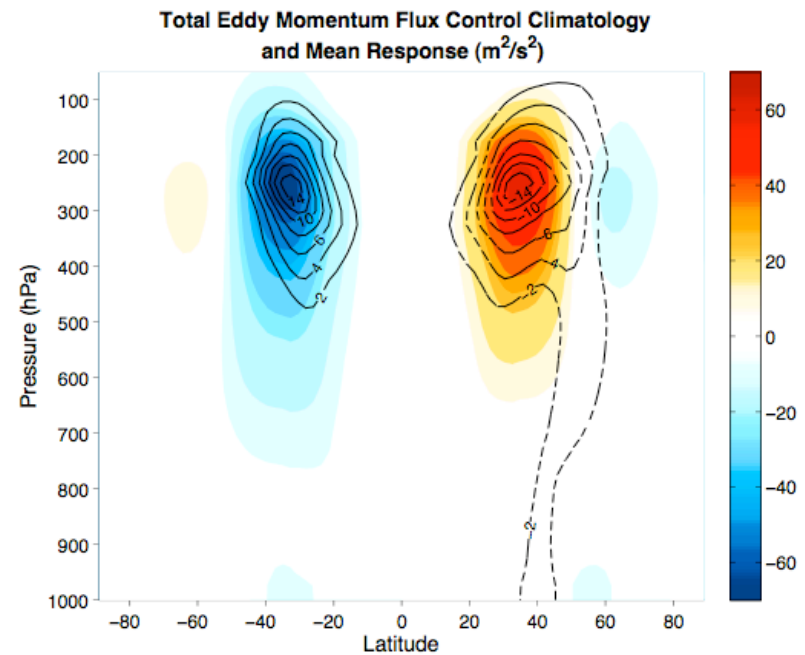
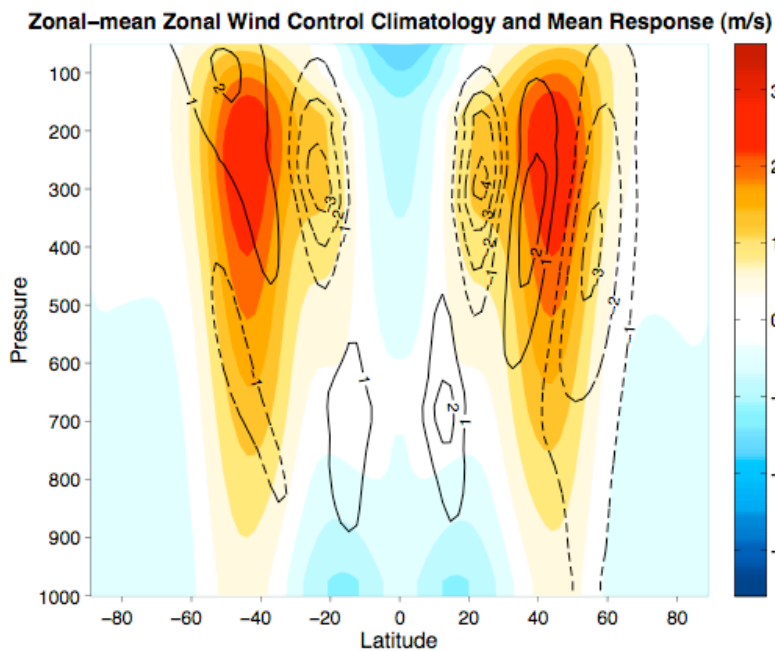
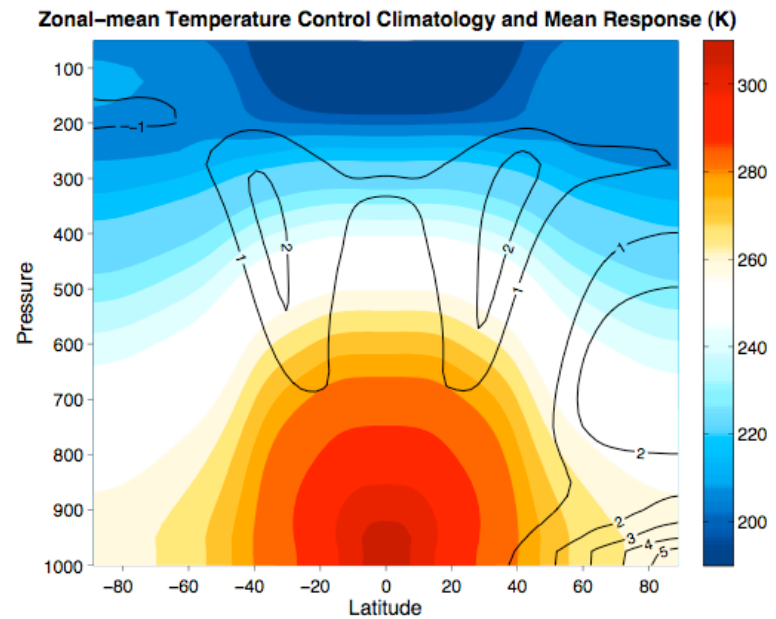
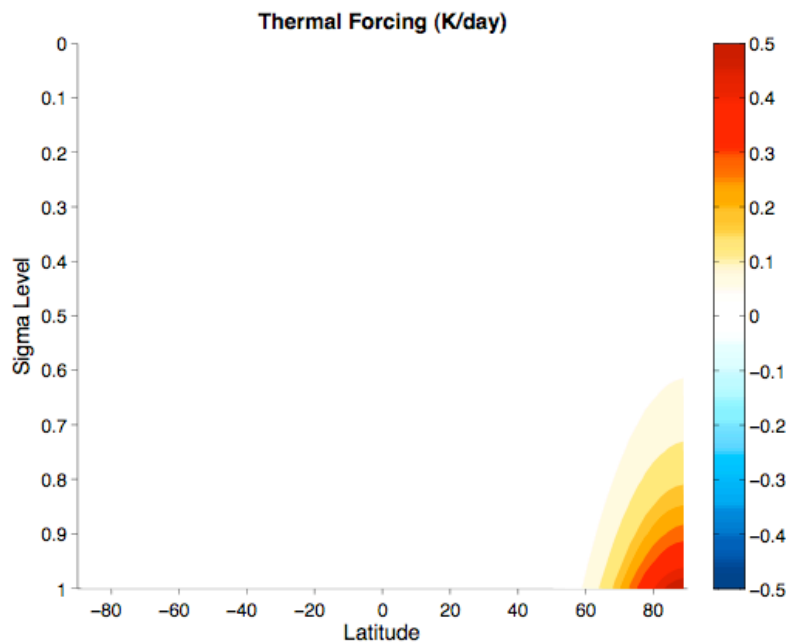
*it is also key for understanding the climate response to anthropogenic emissions*

# understanding the eddy response to thermal forcing (Butler and Thompson in prep)









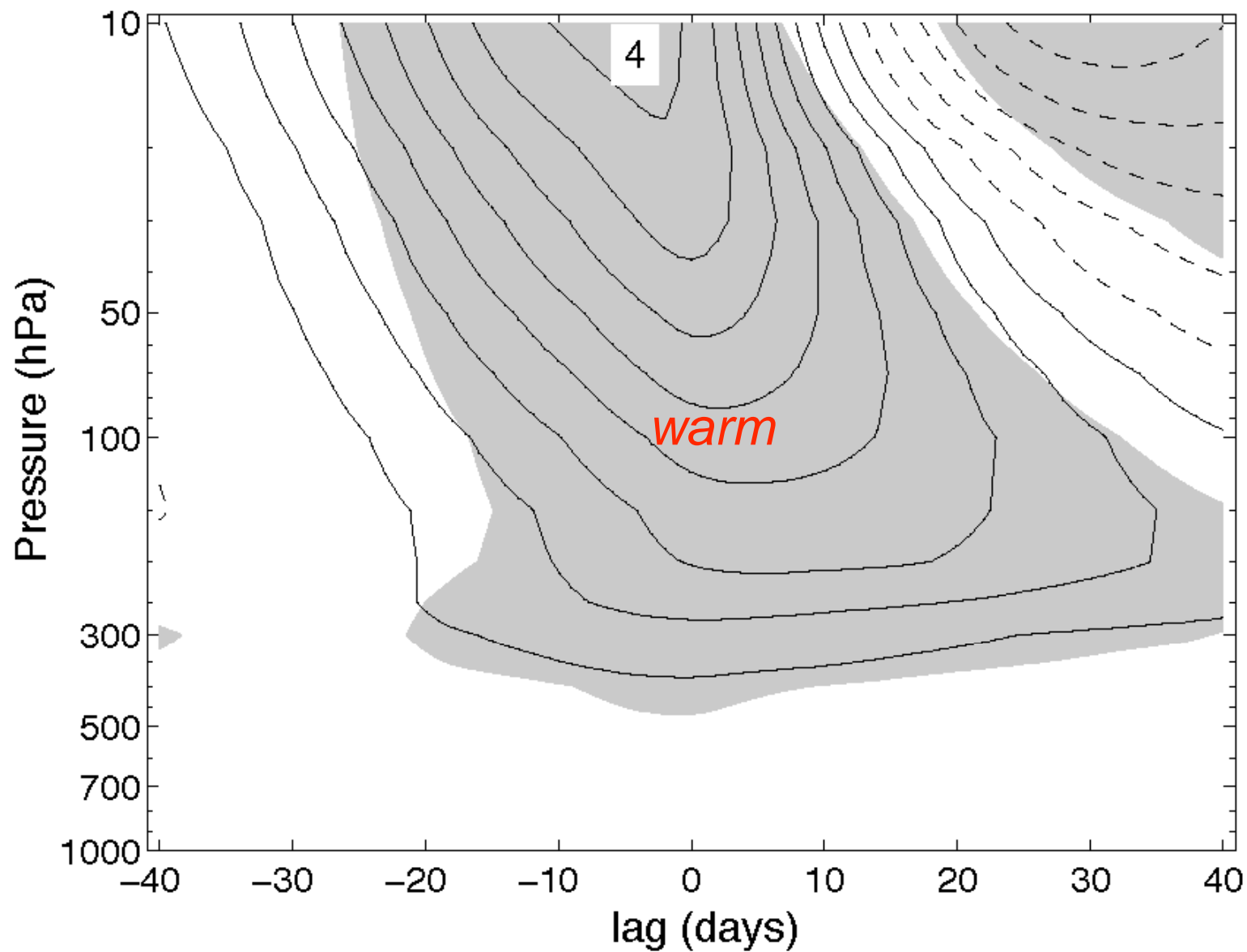
*see also Eichelberger and Hartmann 2005*

conclusions....

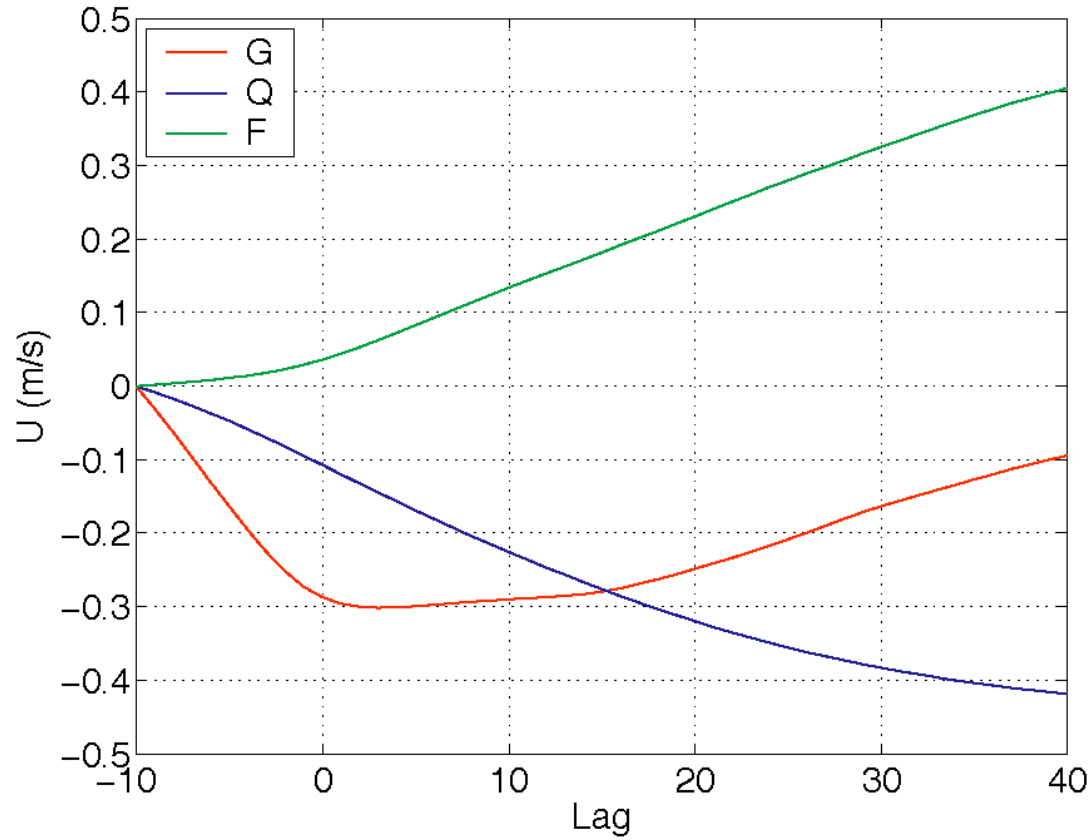
- we know tropospheric eddy feedbacks amplify tropospheric forcing
- we know they almost certainly amplify stratospheric forcing
- we know they are key in climate change simulations.
- but we don't know exactly how they operate.



# Temperature (K) – 50–90°N

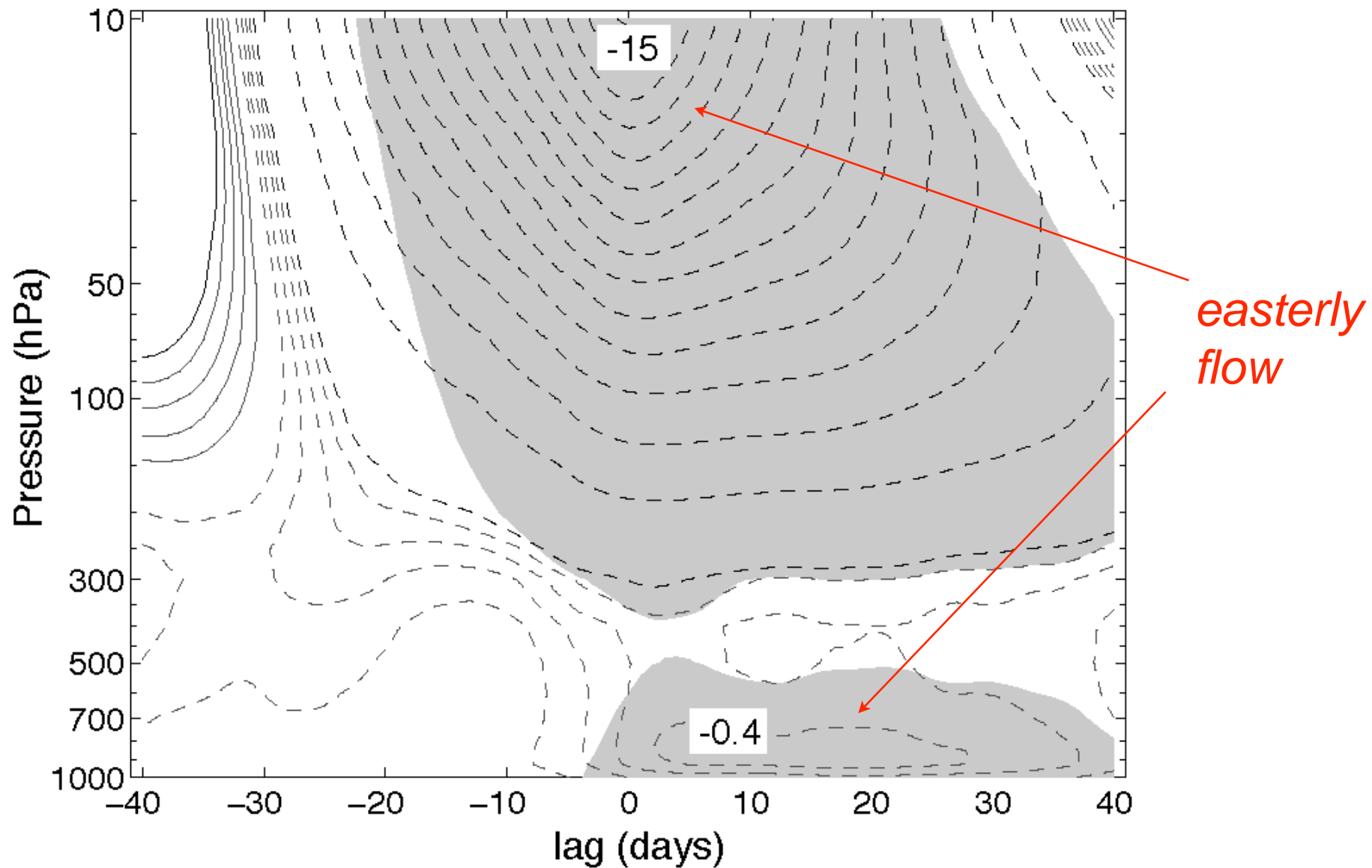


925 hPa Zonal wind integrated response

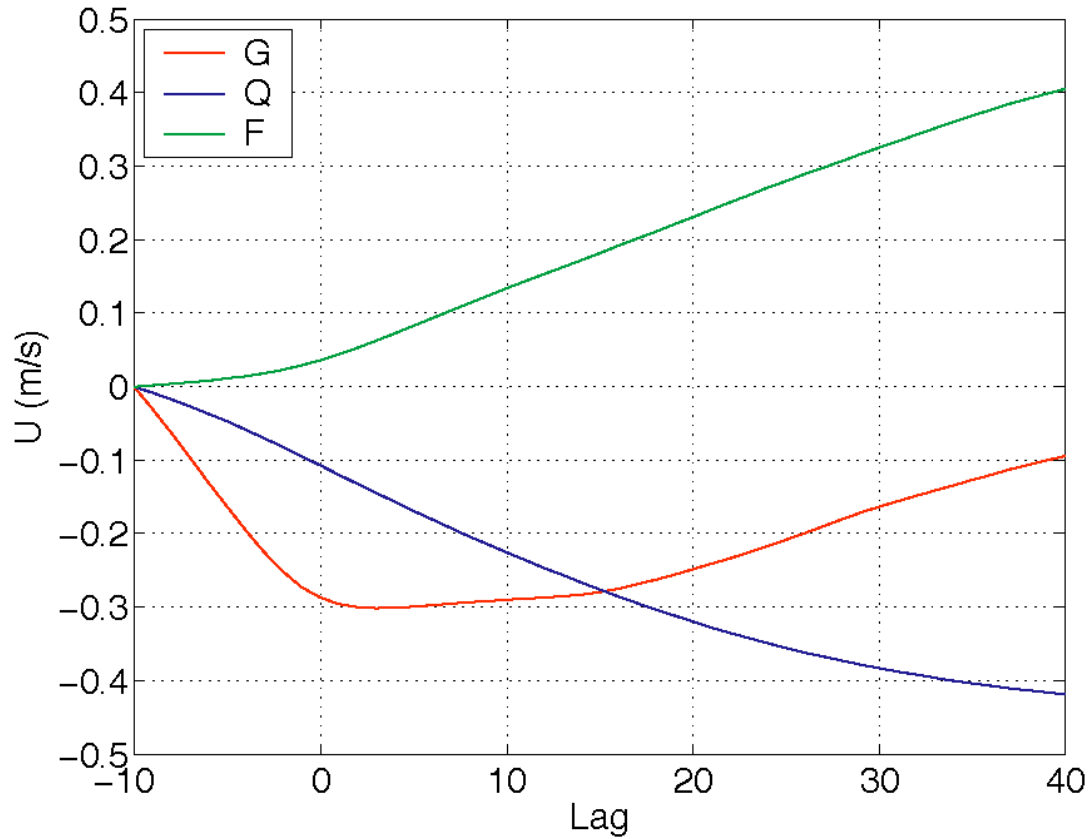


*response to cooling*

# Zonal Mean Zonal Wind (m/s) – 55–75°N

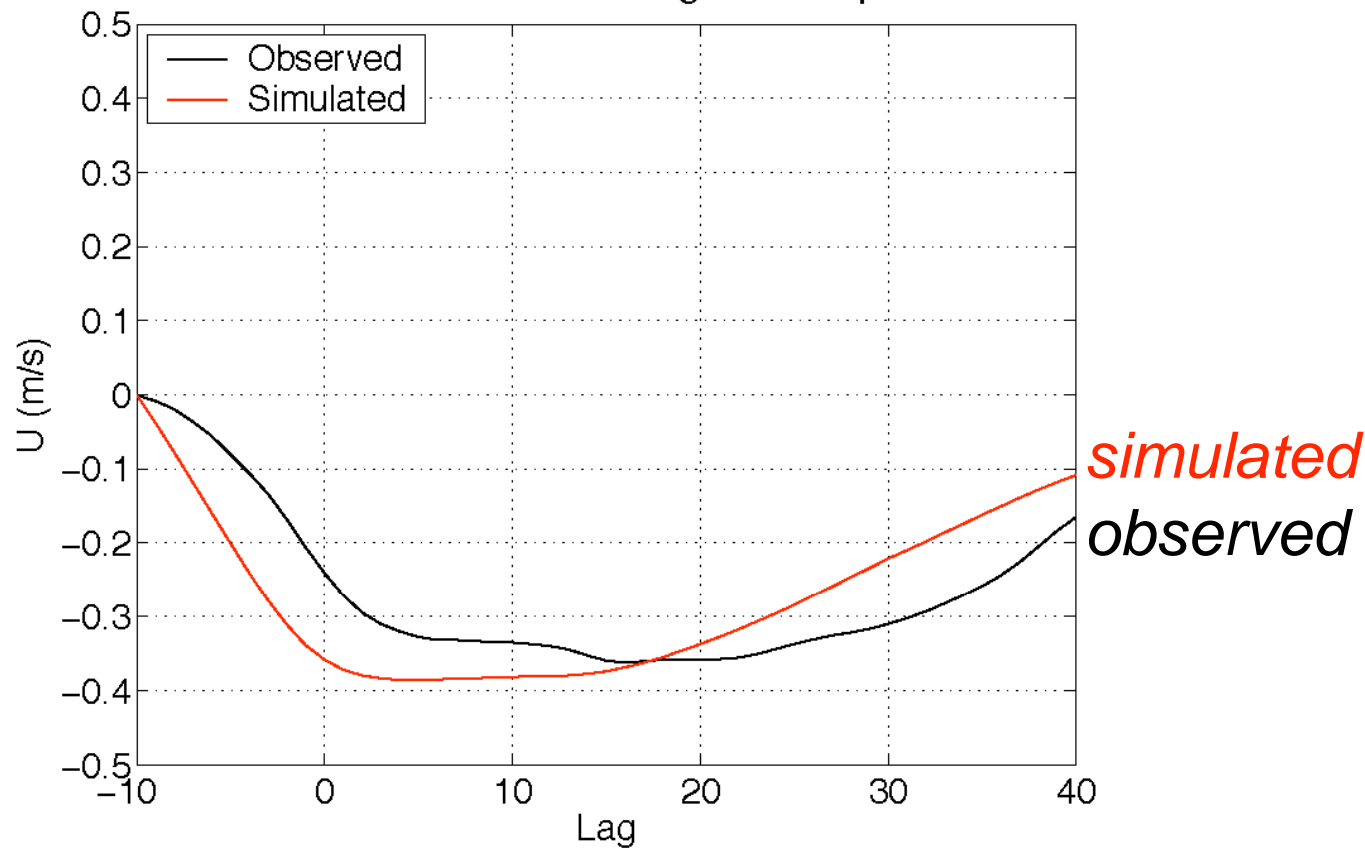


925 hPa Zonal wind integrated response

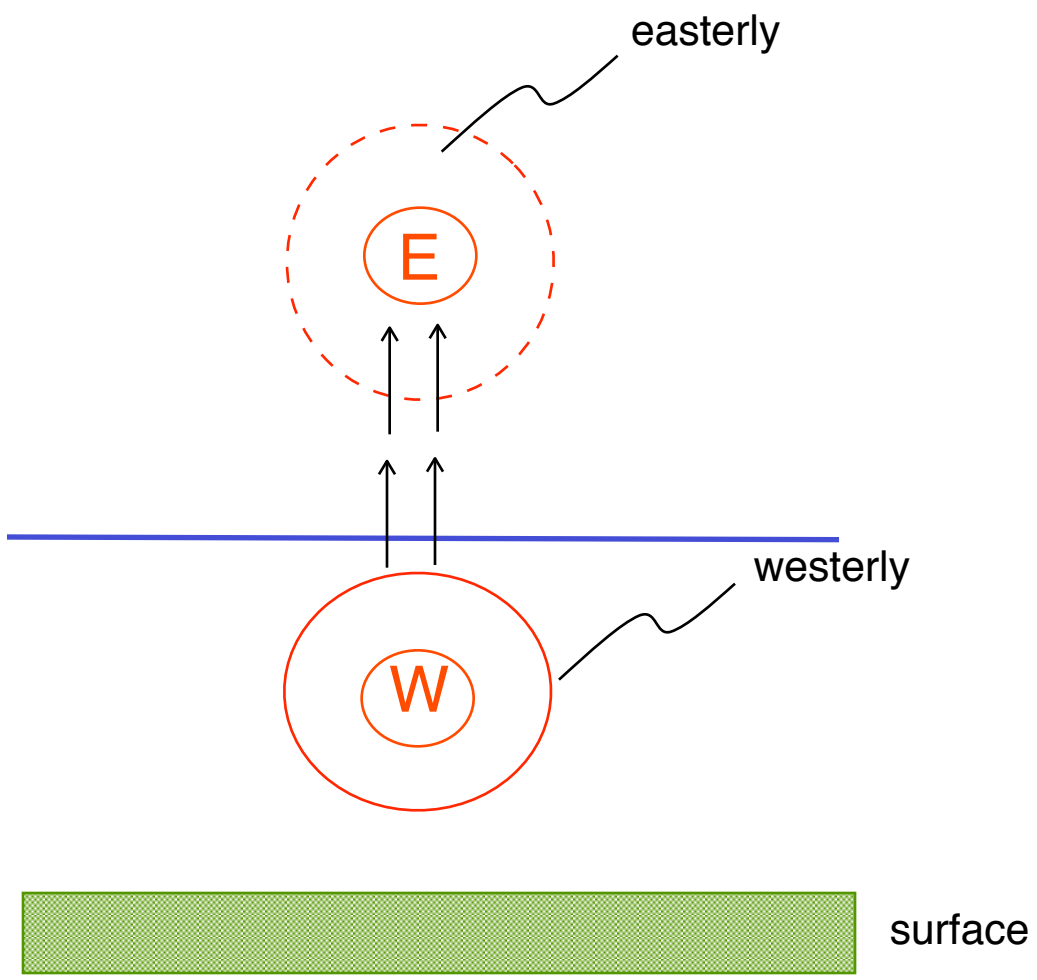


*response to friction*

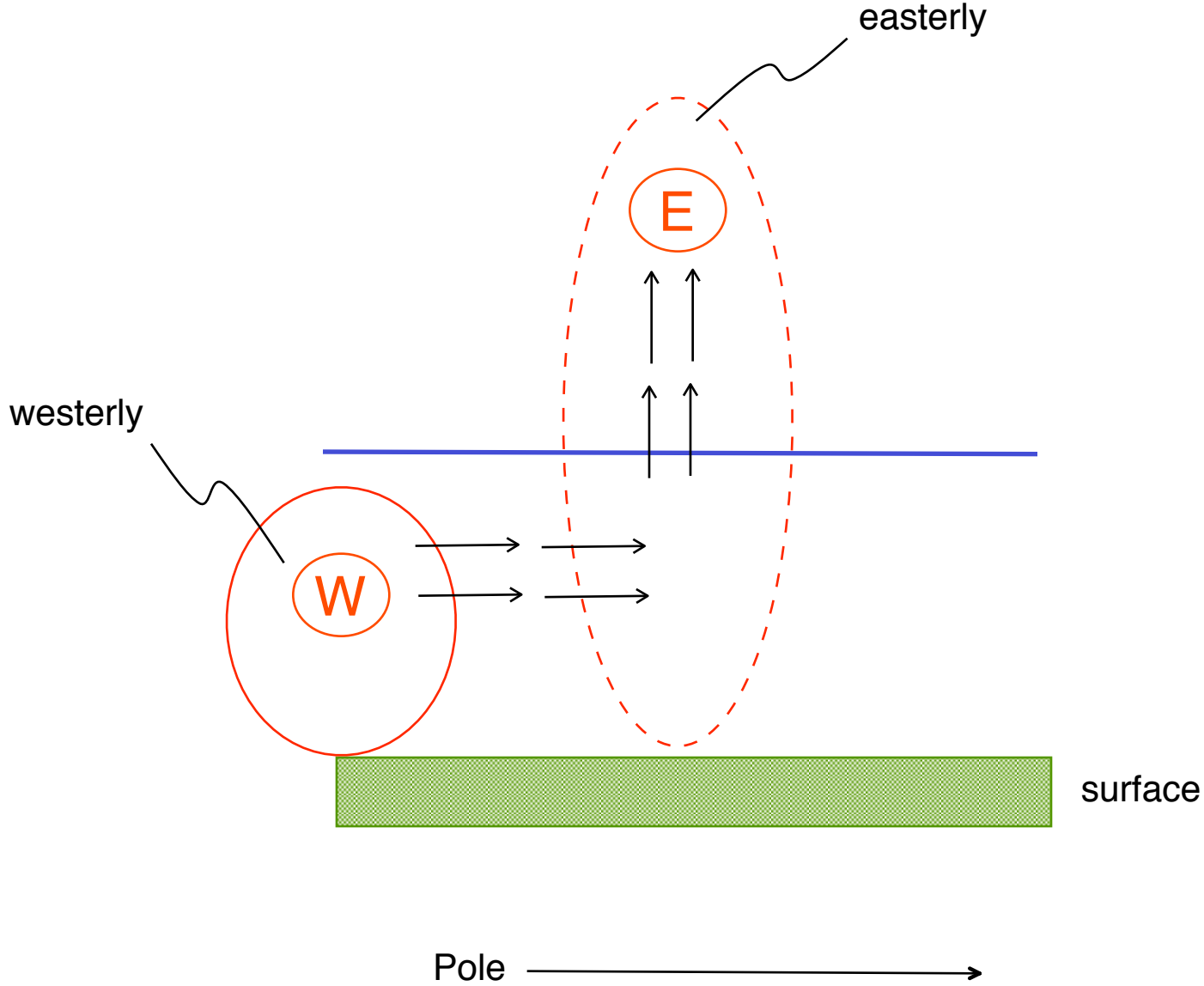
925 hPa Zonal wind integrated response





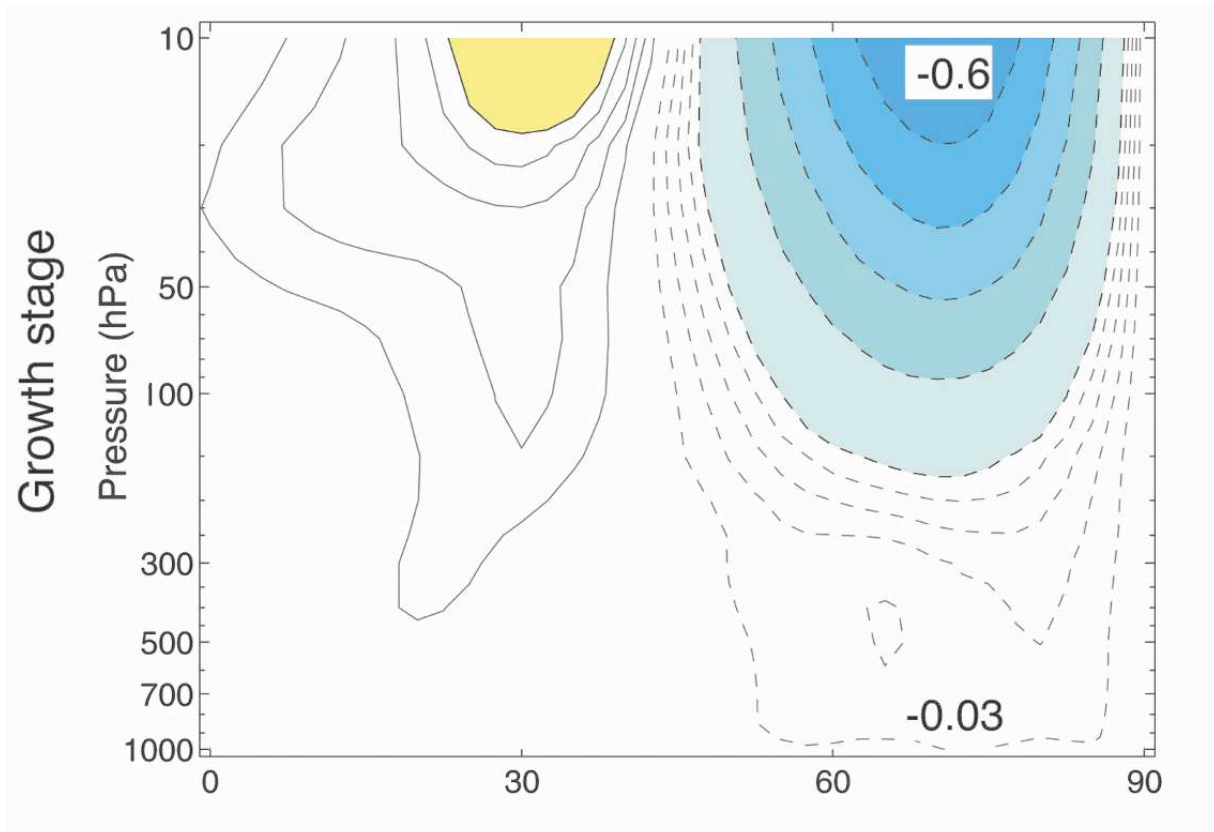


Pole →



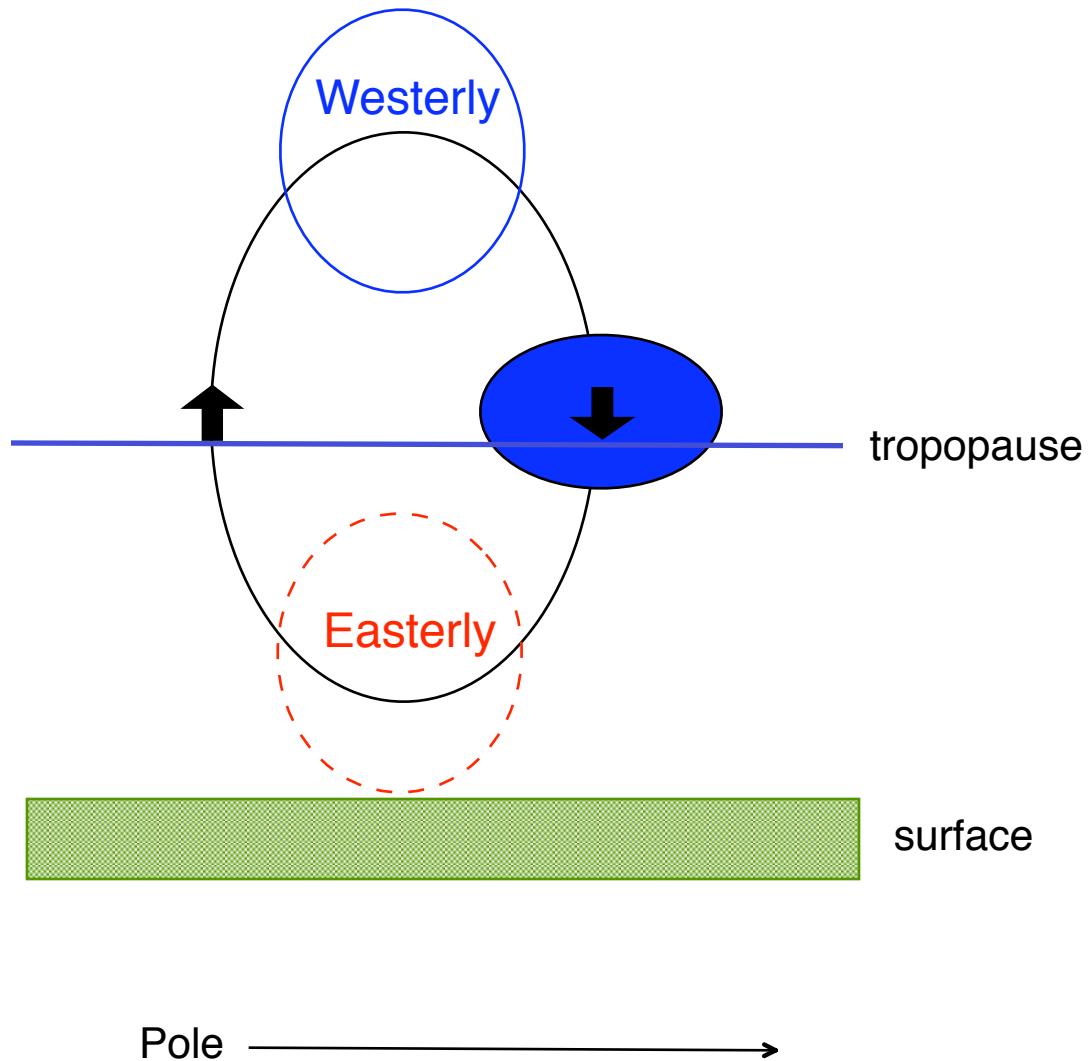
- 
- The amplitude and persistence of the tropospheric response are consistent with the balanced response to stratospheric wave drag/diabatic heating.
  - But the barotropic structure of the response requires changes in the tropospheric momentum fluxes.
  - Understanding stratosphere/troposphere coupling requires understanding internal tropospheric dynamics.

- Changes in the zonal flow in the lower stratosphere/upper troposphere change the eddy flux of momentum there.

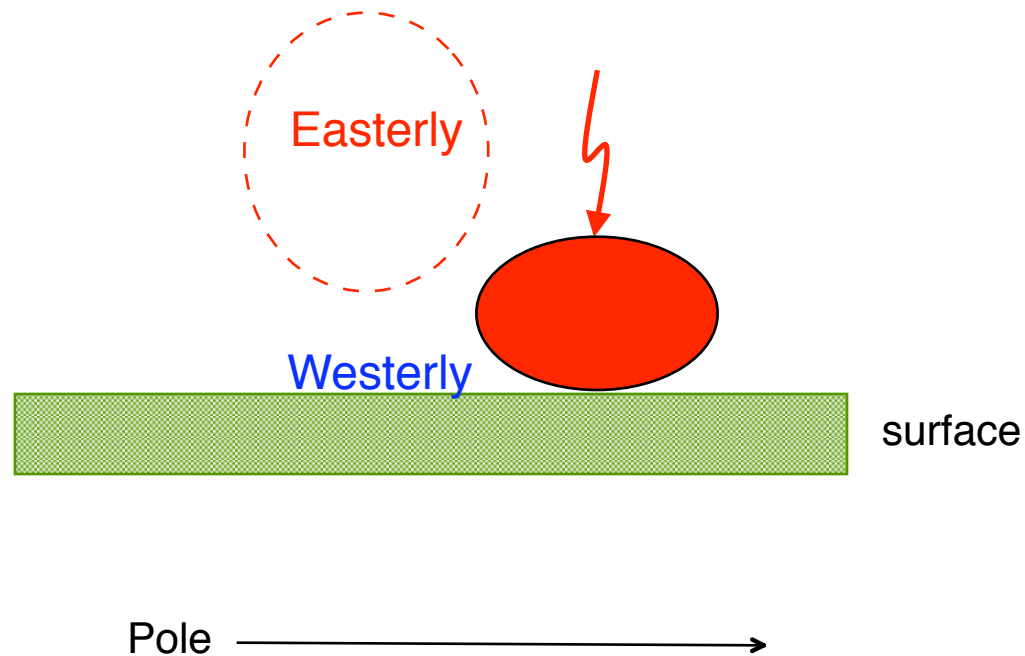


# a) circulation driven by stratospheric cooling

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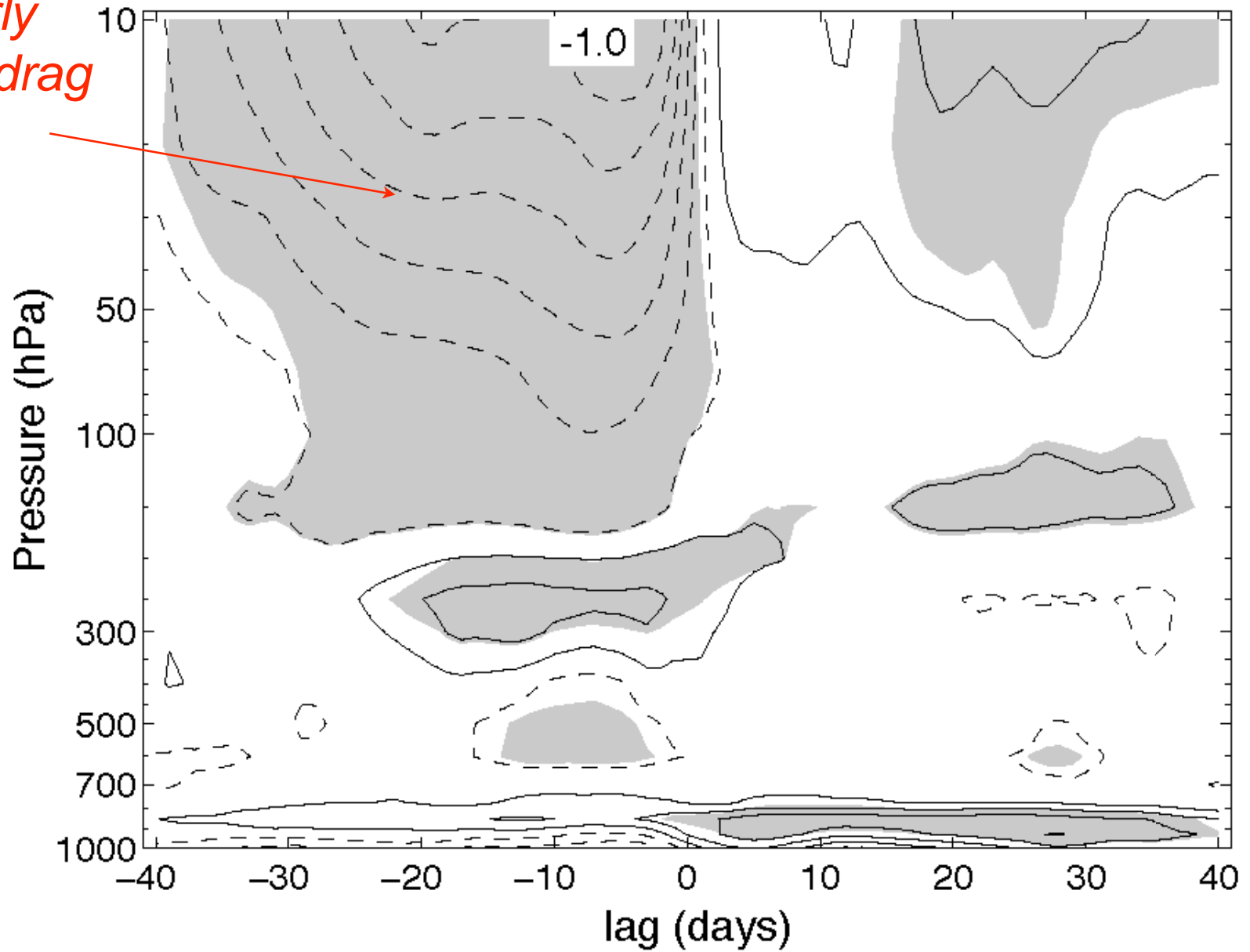


## b) circulation driven by tropospheric warming



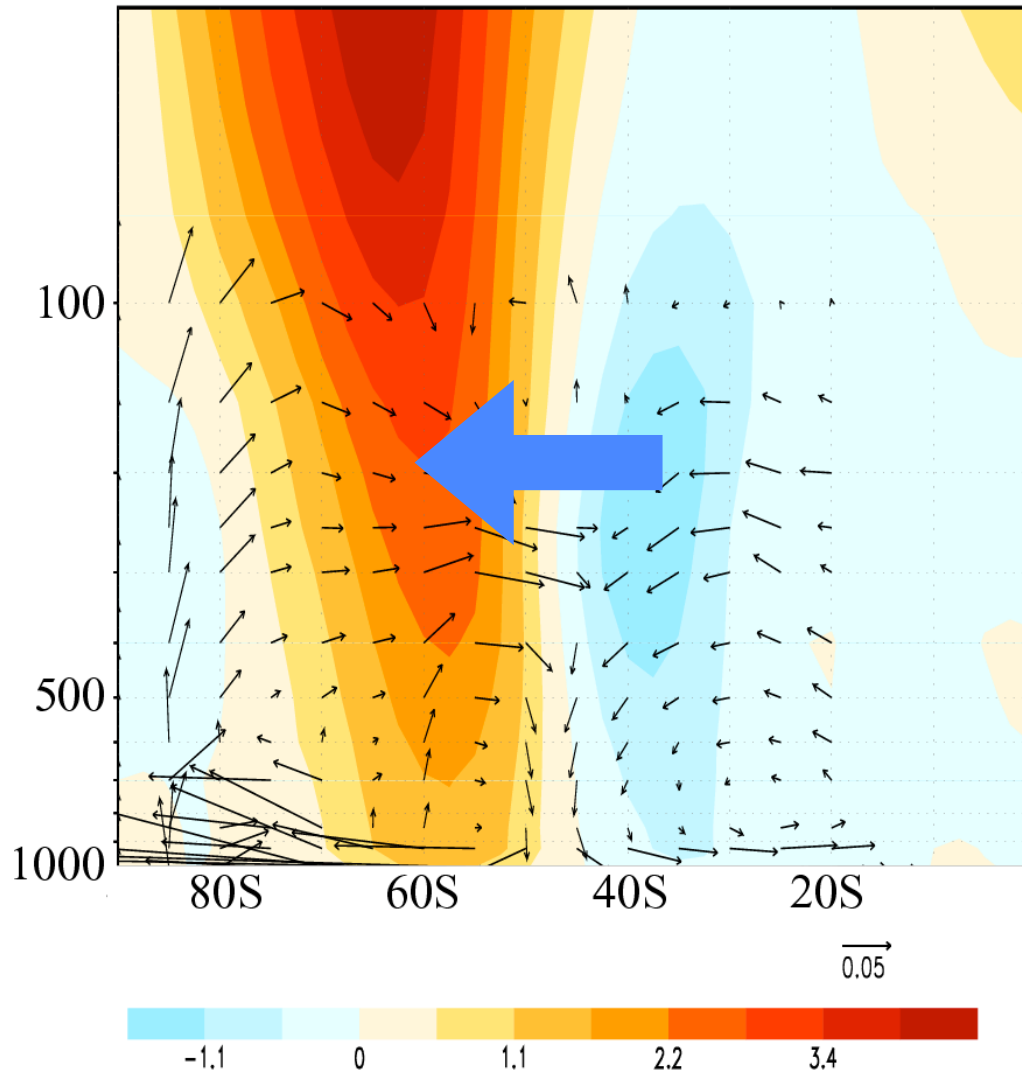
# EP flux divergence (m/s/day) – 55–75°N

*easterly  
wave drag*



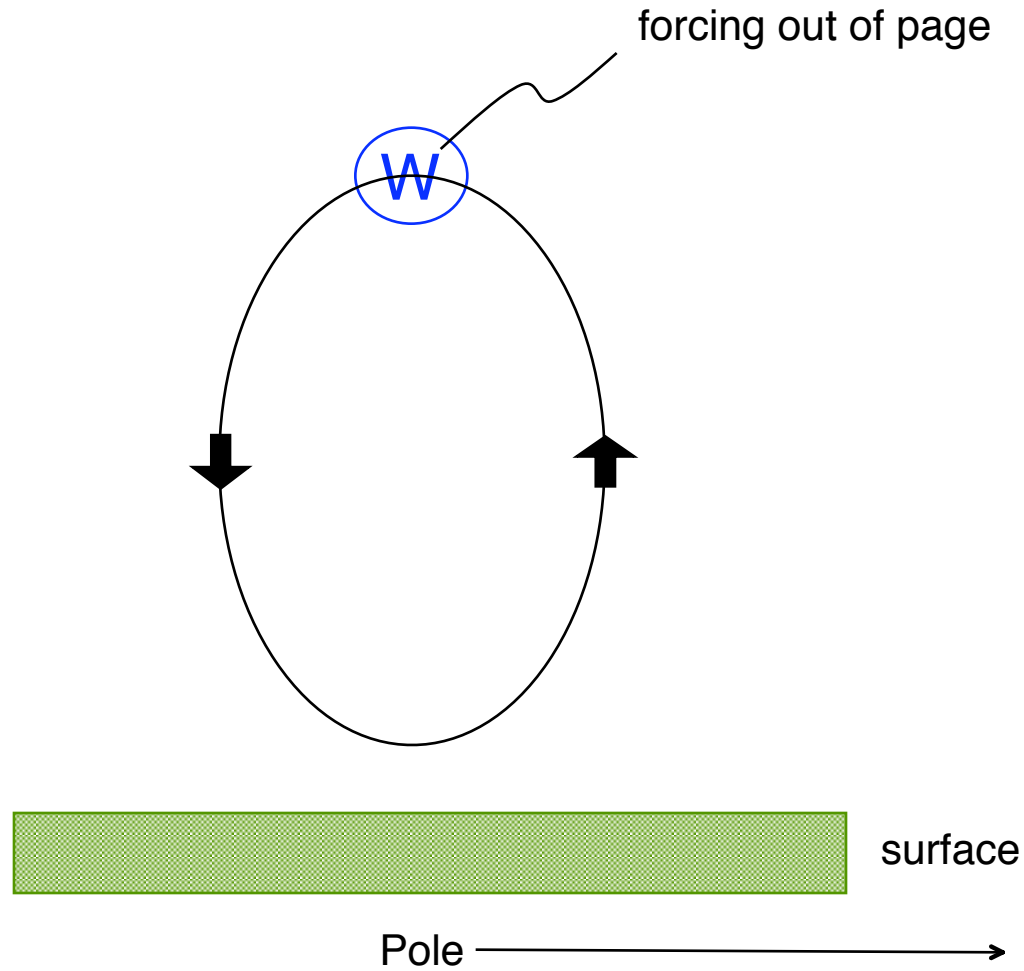
# [U] regressed on SH annular mode

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*stratospheric and tropospheric flow are coupled*





*simple to visualize how momentum fluxes can drive [U]*

