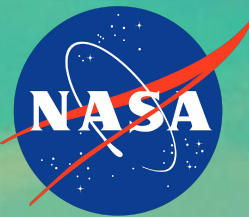


# The Anomalous Warming of the SH Subtropical Lower Stratosphere and Implications for Detecting Antarctic Ozone Recovery

Aodhan Sweeney  
COSMIC/JCSDA IROWG-10  
September 17th, 2024

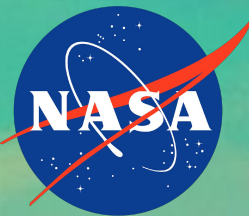
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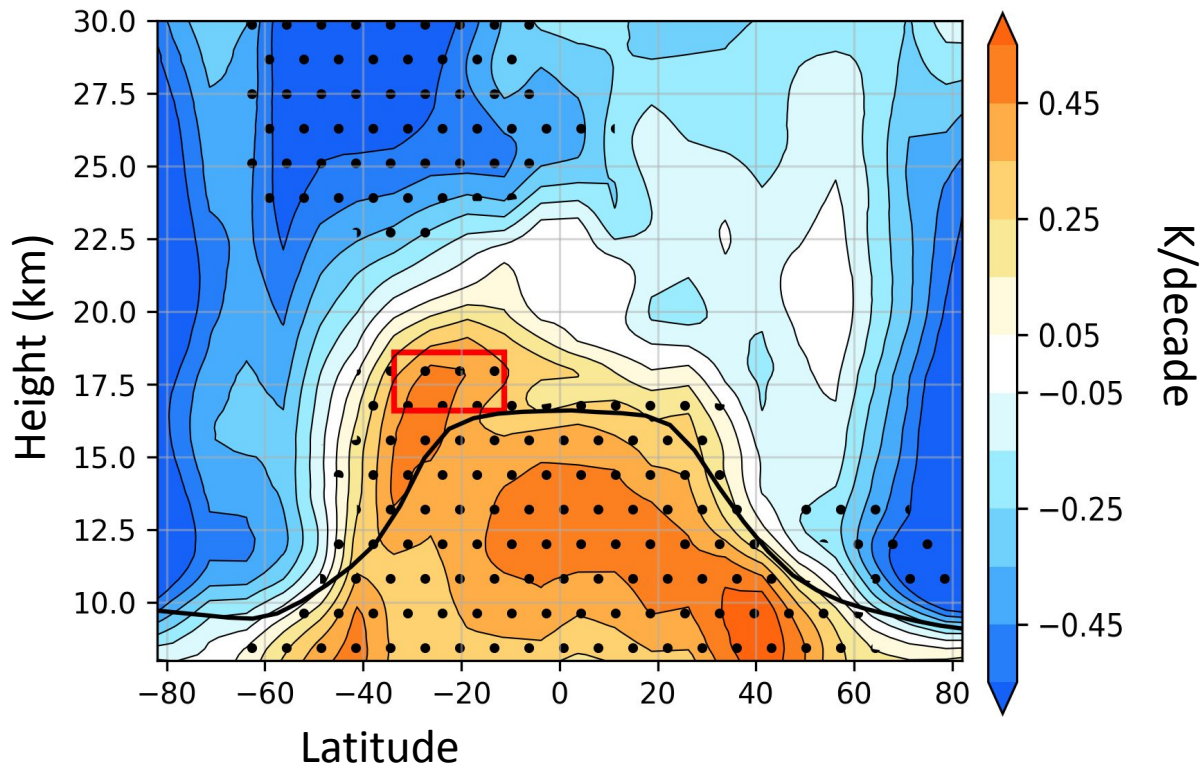
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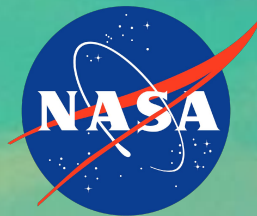
GNSS-RO Trends 2002-2022



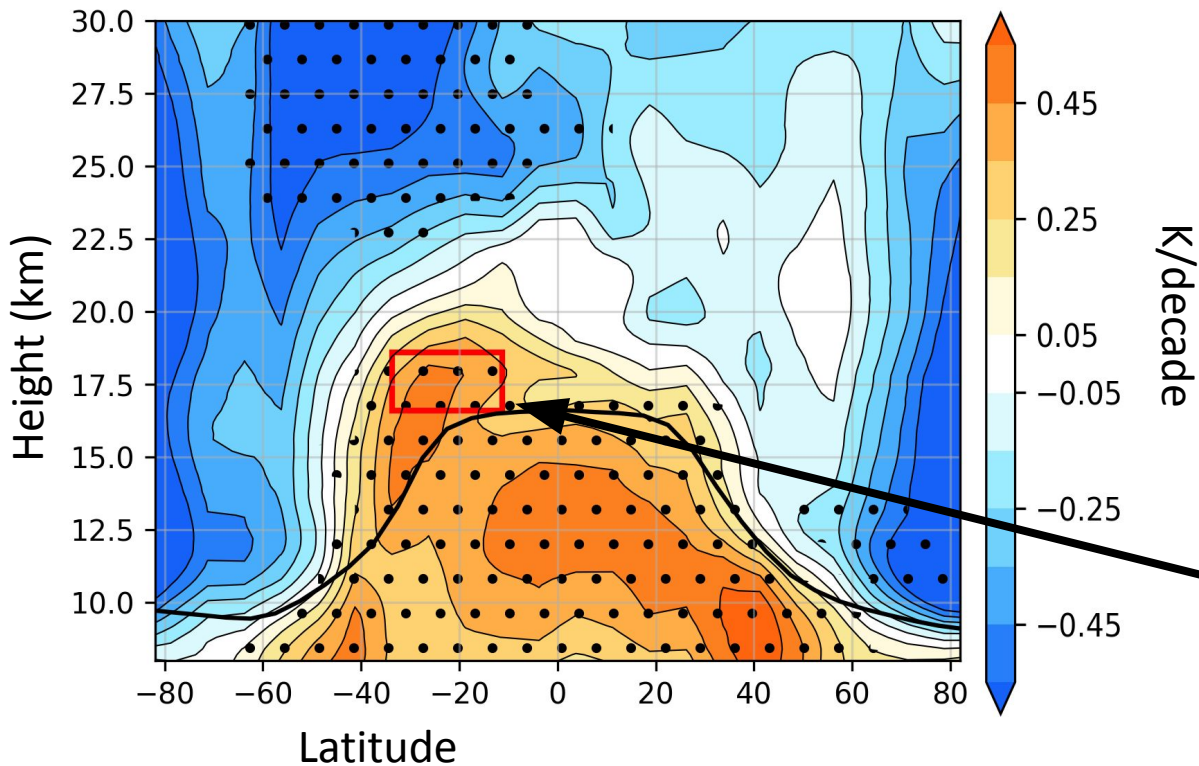
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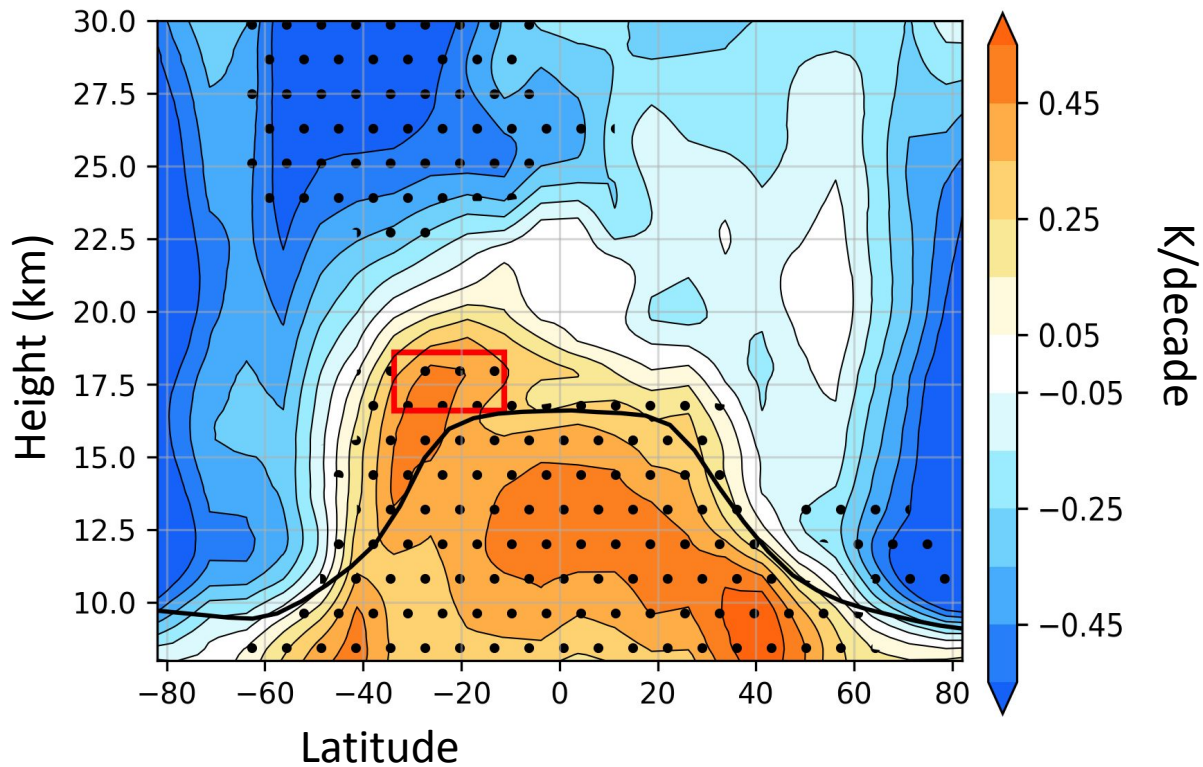
GNSS-RO Trends 2002-2022



Anomalous Warming of  
the Lower Stratosphere  
(AWLS)

# The Anomalous Warming of the SH Subtropical Lower Stratosphere and Implications for Detecting Antarctic Ozone Recovery

GNSS-RO Trends 2002-2022

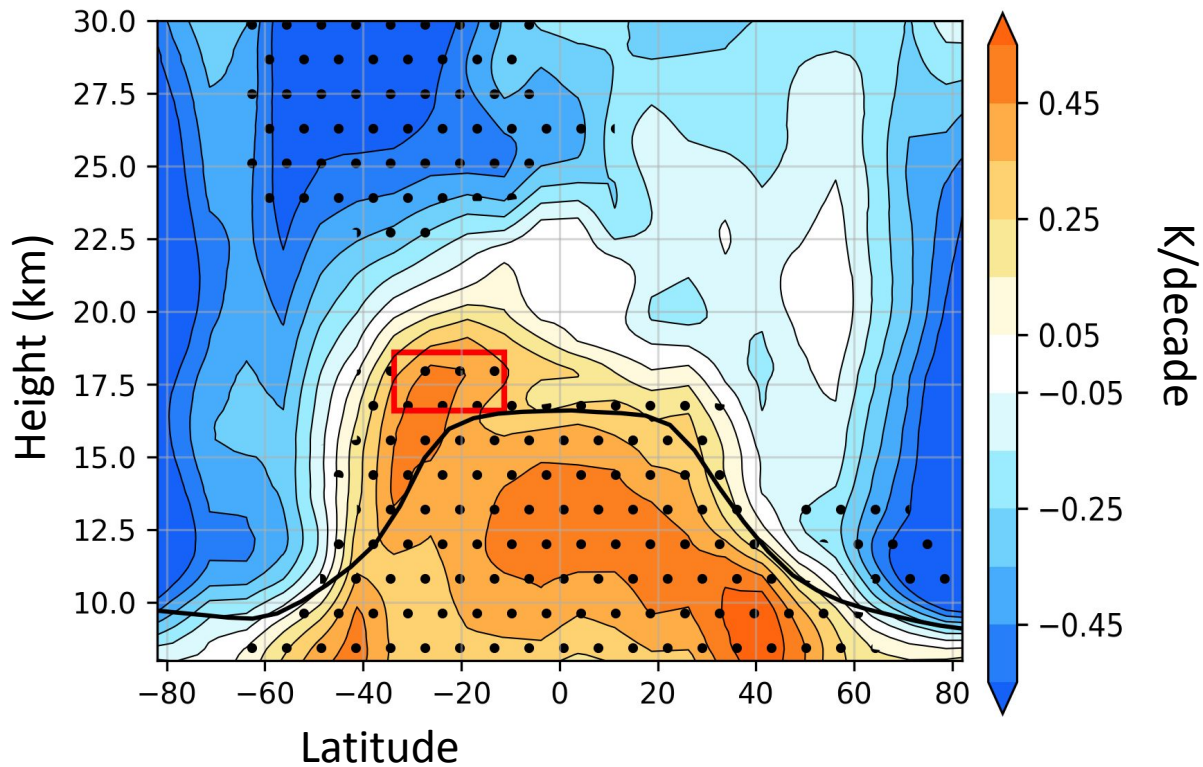


## Outline/ Main Points:

1. The AWLS is dynamically induced
2. Dynamics may mask signal of ozone recovery

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GNSS-RO Trends 2002-2022

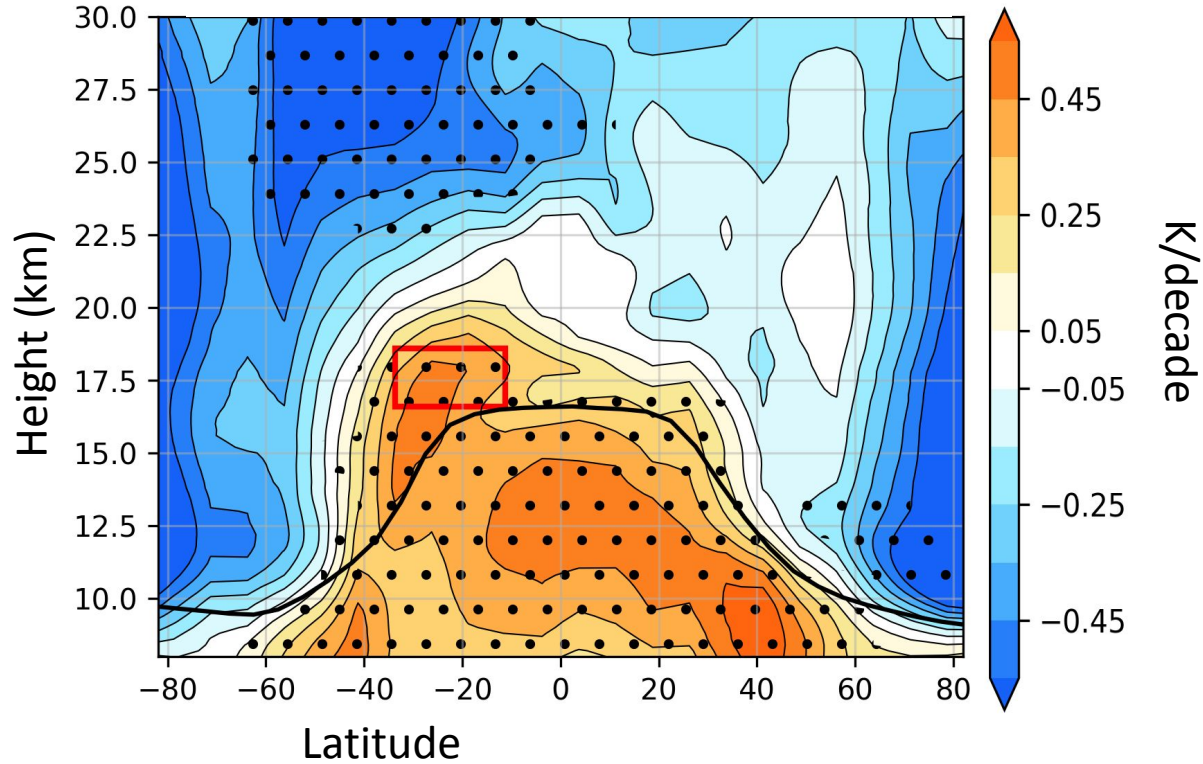


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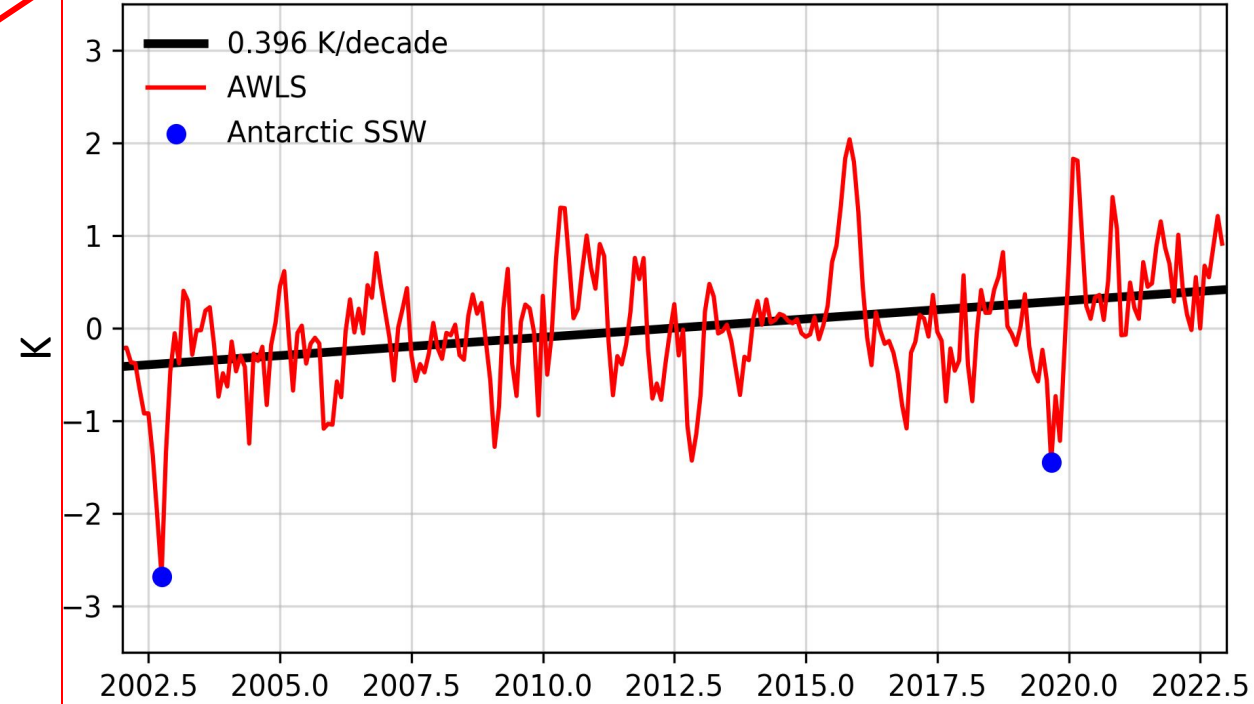
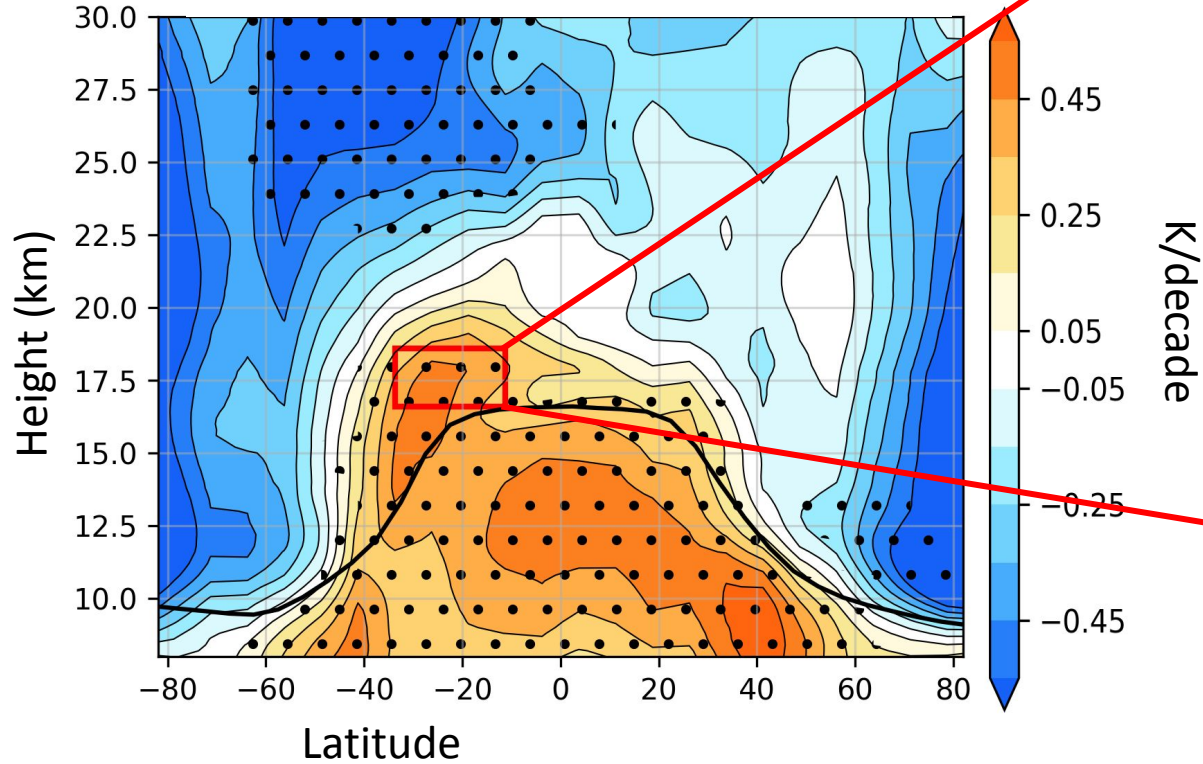
# The AWLS is dynamically induced

GNSS Temperature Trends  
2002-2022



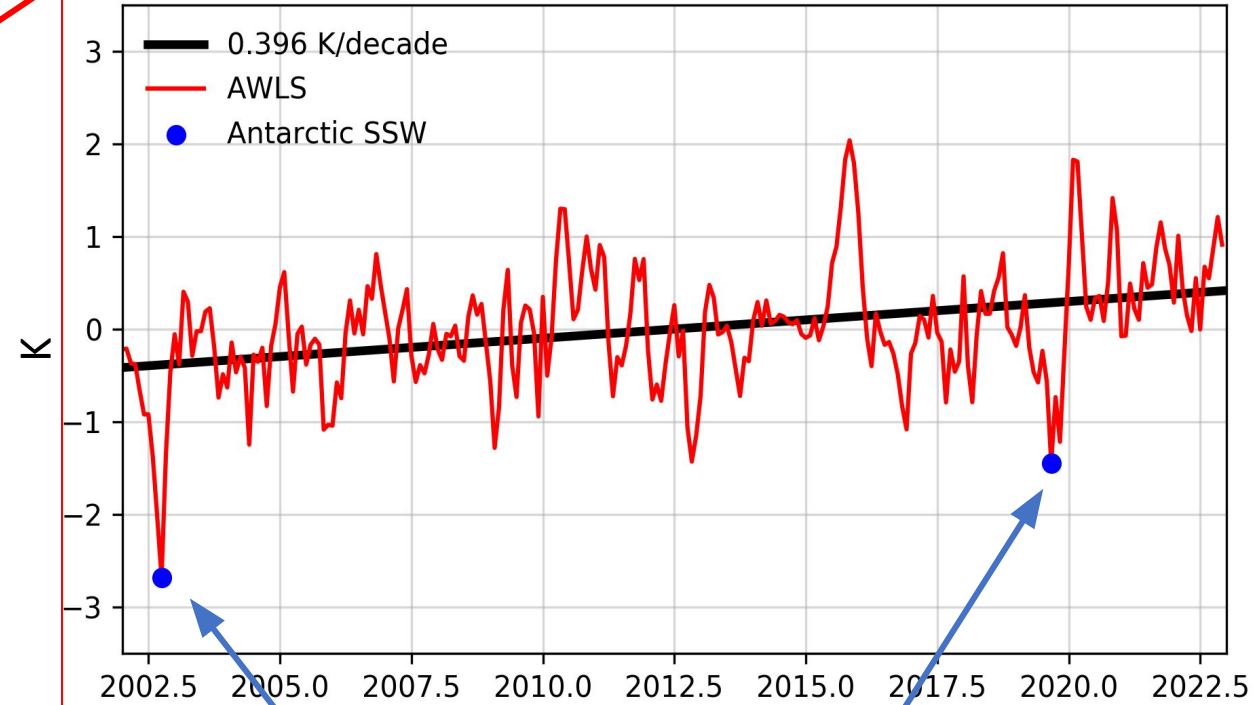
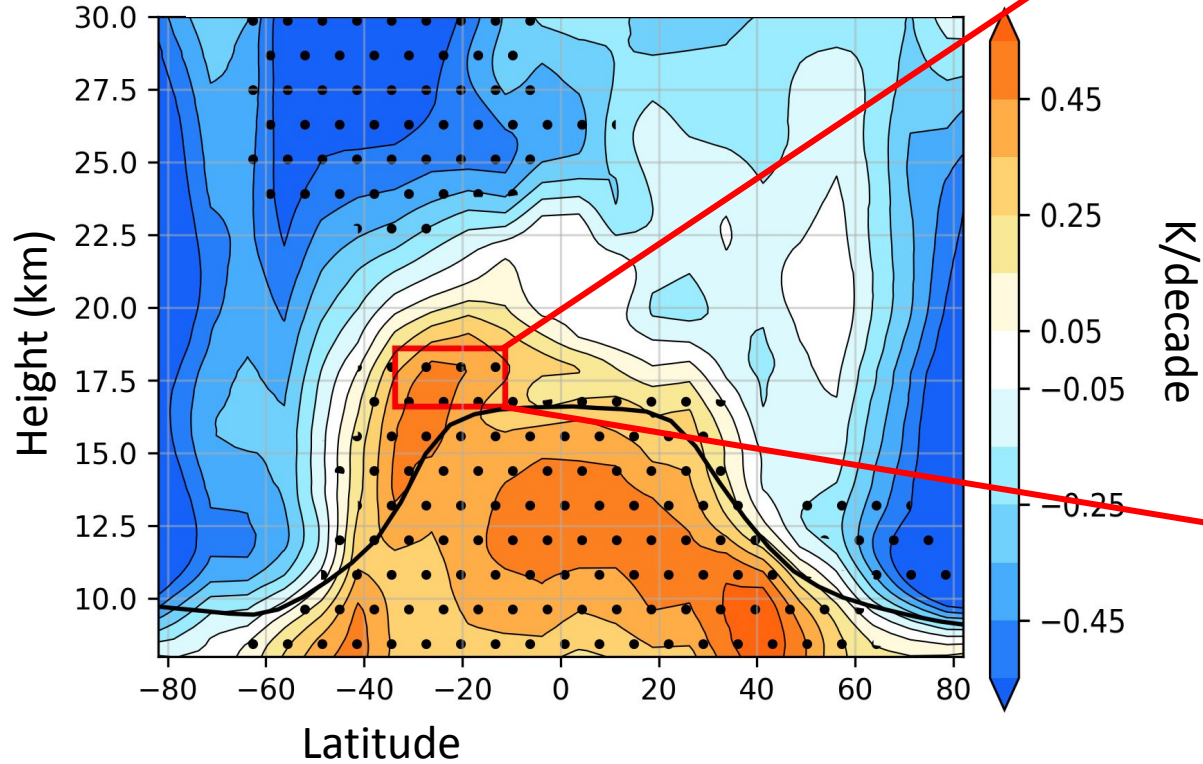
# The AWLS is dynamically induced

## GNSS Temperature Trends 2002-2022



# The AWLS is dynamically induced

## GNSS Temperature Trends 2002-2022

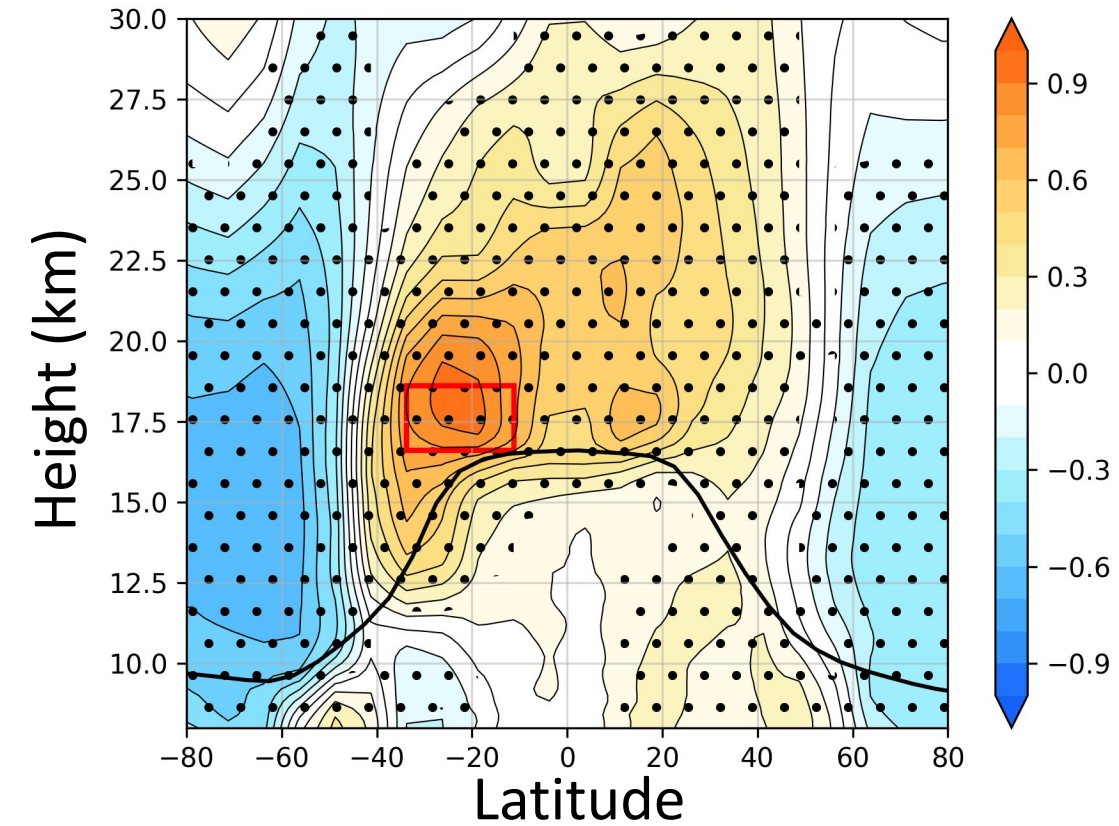


The 2002 and 2019  
Antarctic Sudden  
Stratospheric Warmings



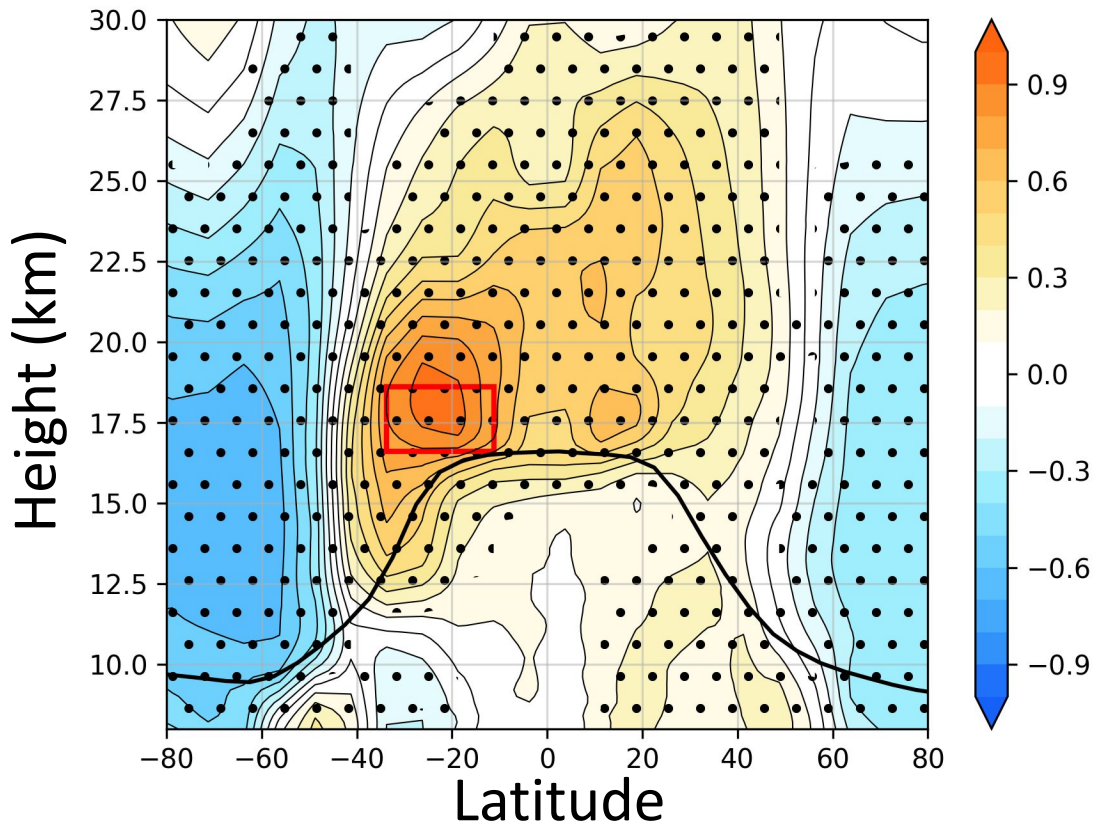
# The AWLS is dynamically induced

Correlations of AWLS and  
Temperature (detrended)

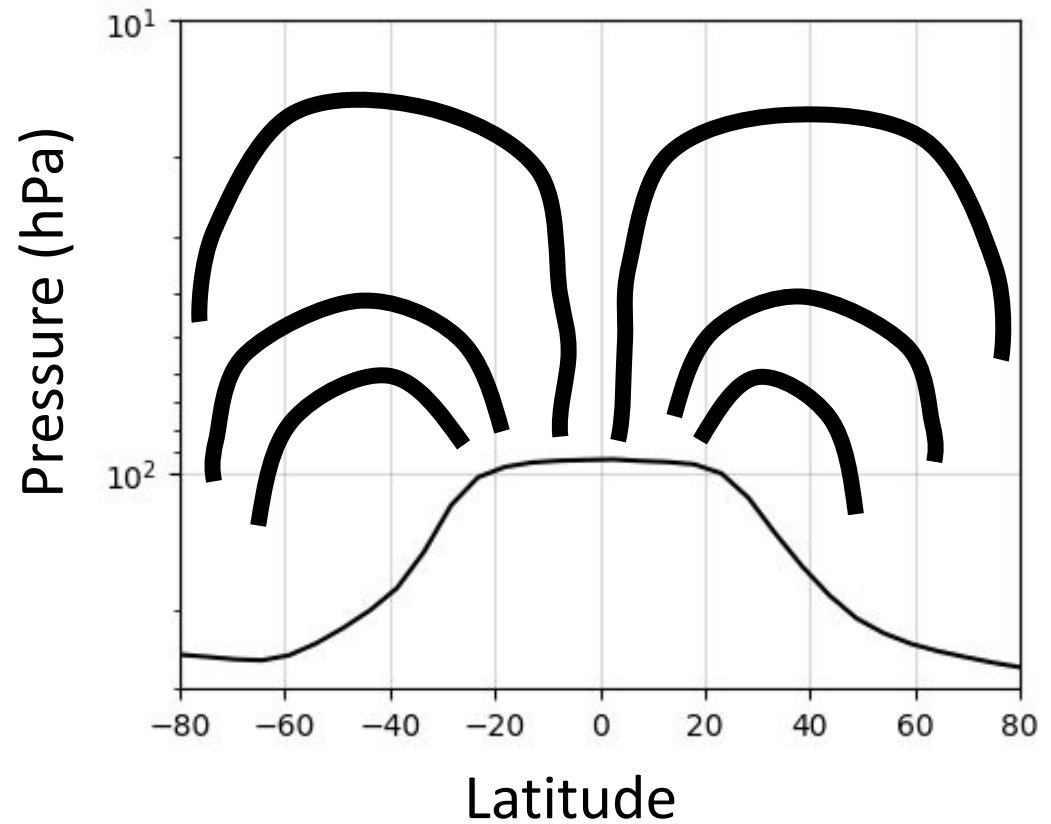


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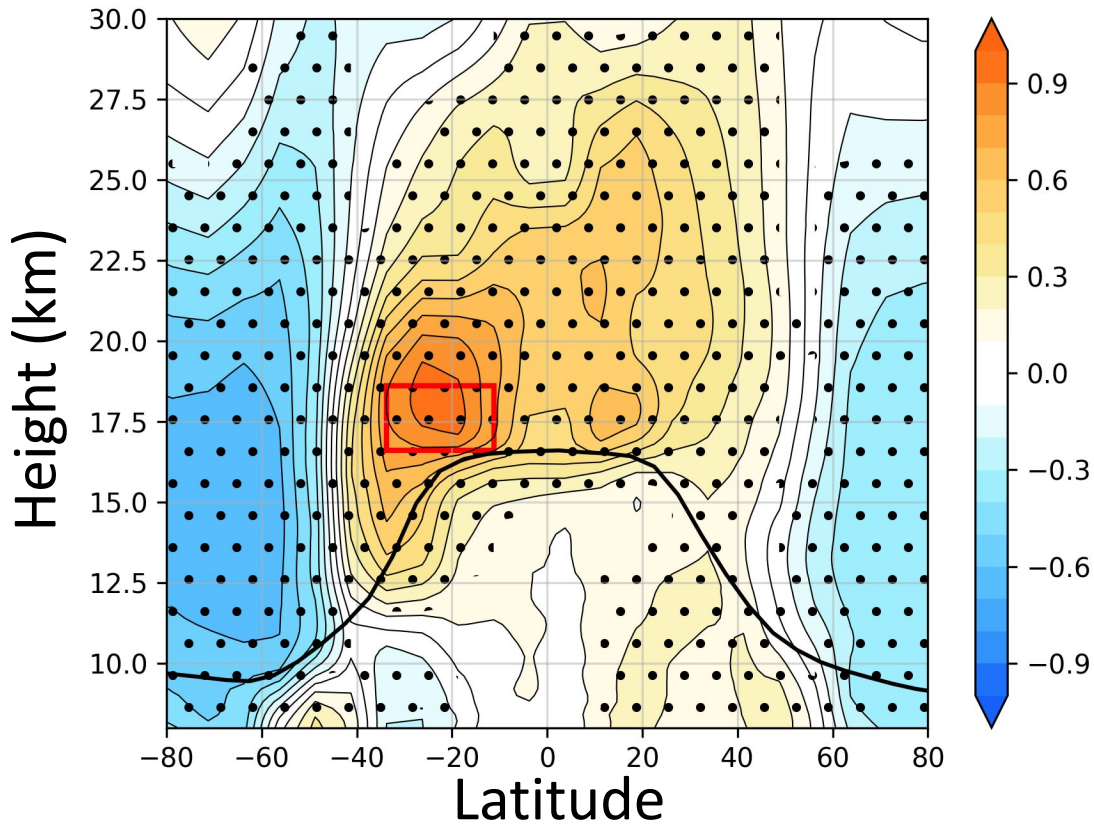


## Schematic of Stratospheric Circulation

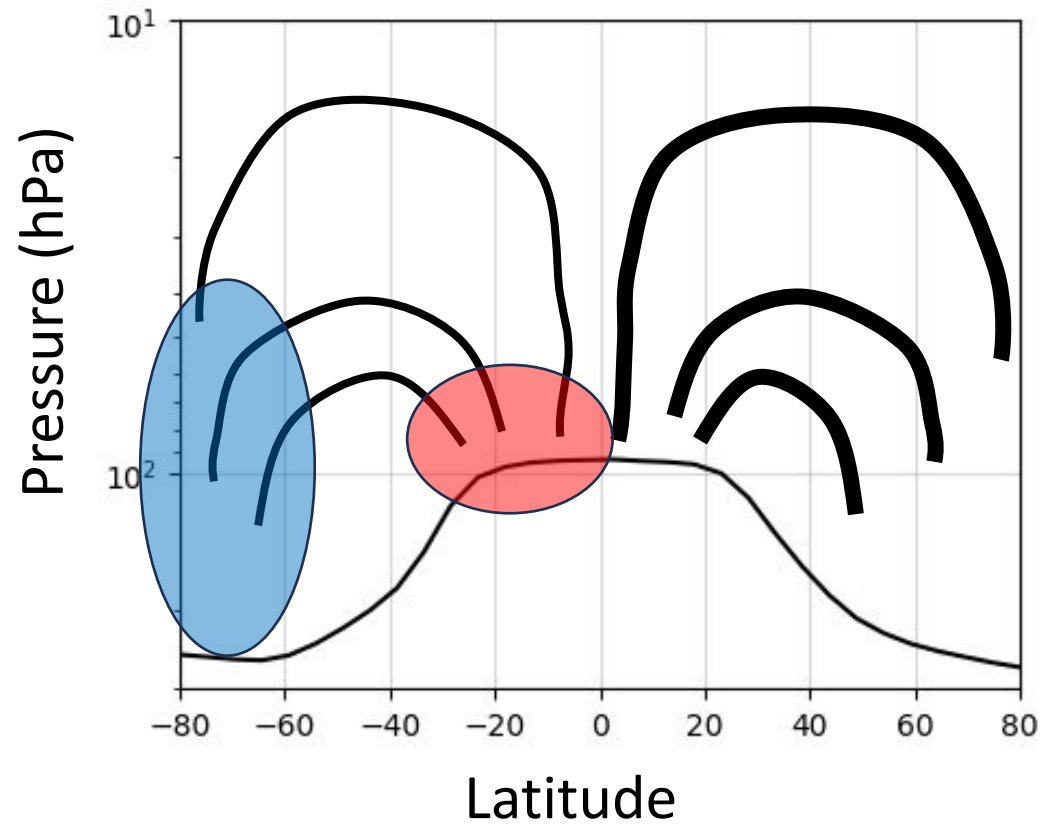


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## Correlations of AWLS and Temperature (detrended)

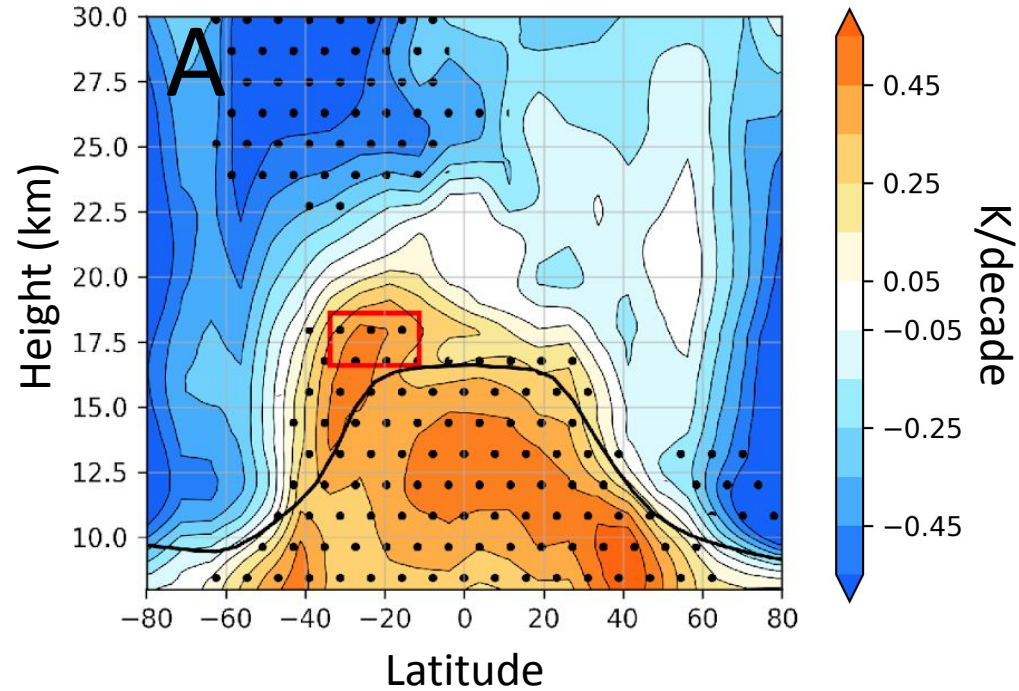


## Weakened Stratospheric Circulation



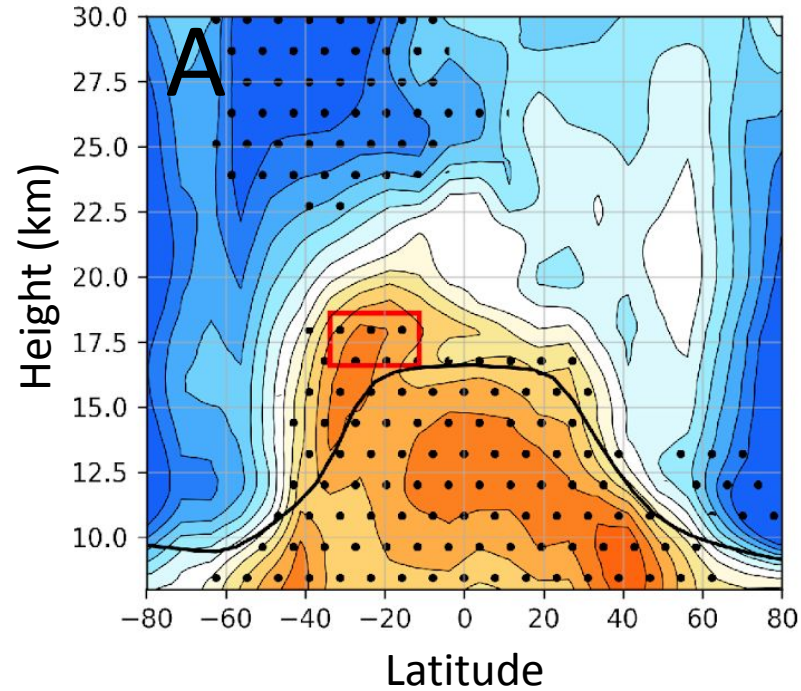
# The AWLS is dynamically induced

Temperature Trends  
(2002-2022)

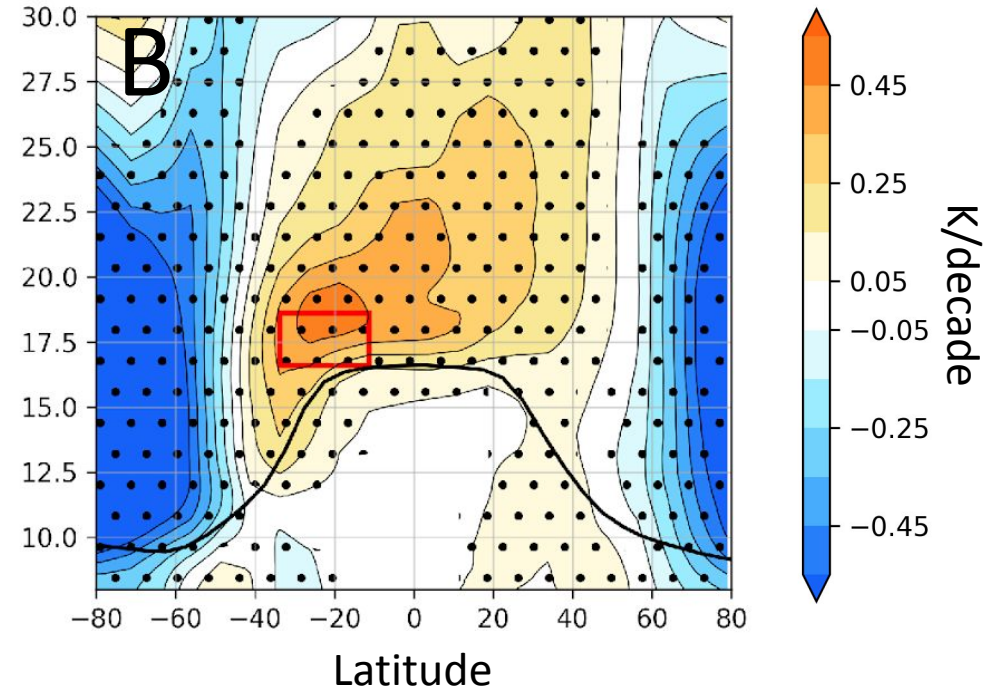


# The AWLS is dynamically induced

Temperature Trends  
(2002-2022)

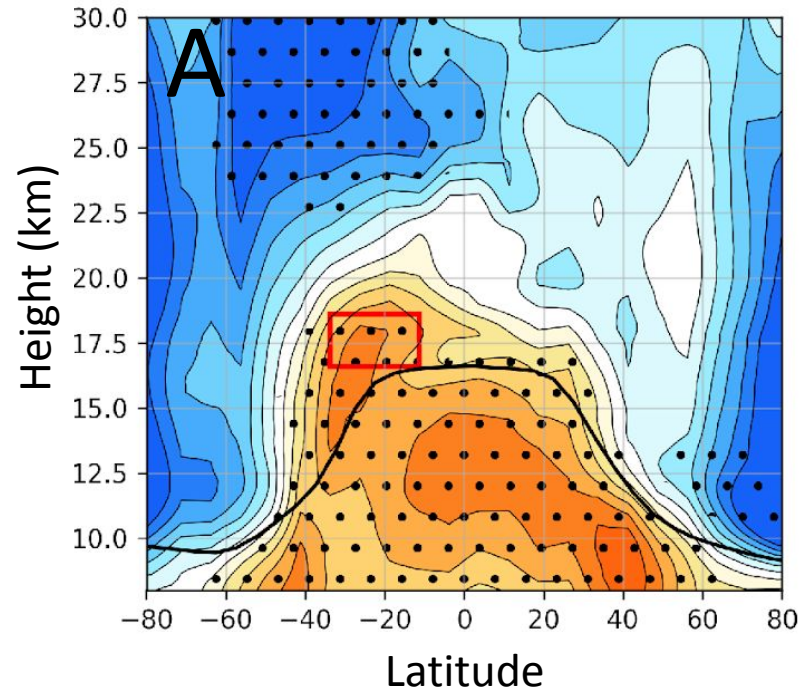


Trends from  
Circulation Regression

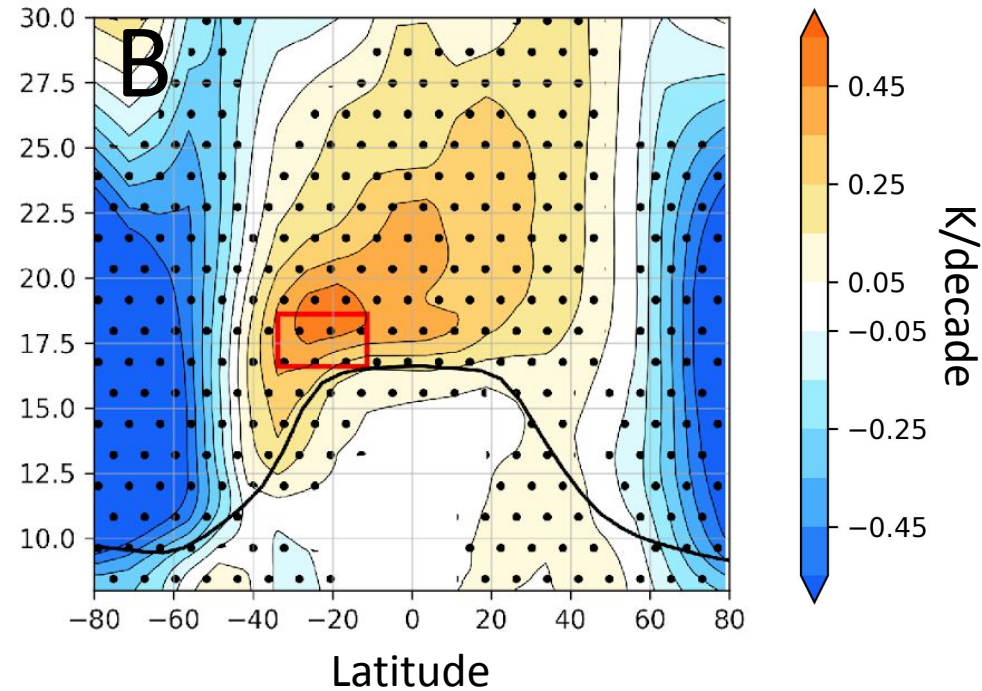


# The AWLS is dynamically induced

Temperature Trends  
(2002-2022)



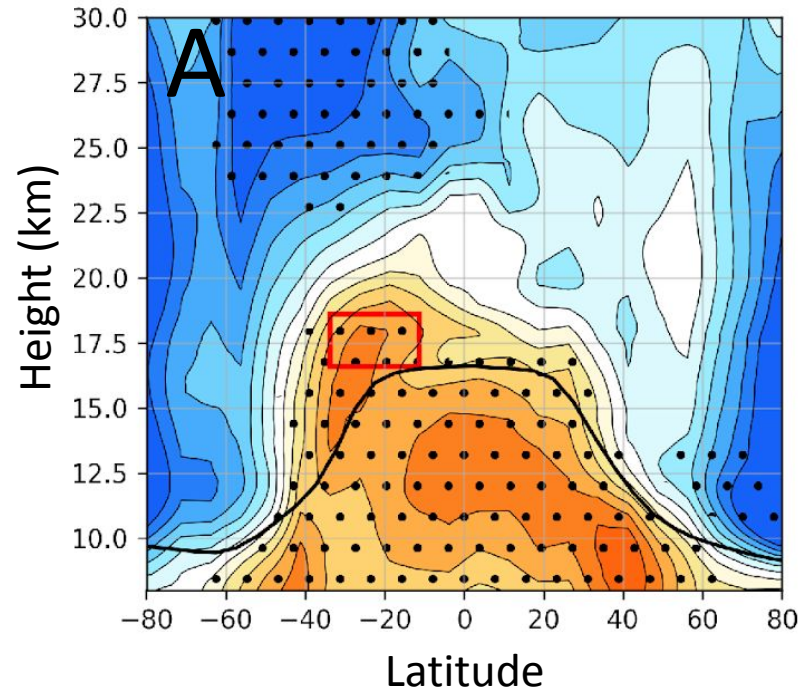
Trends from  
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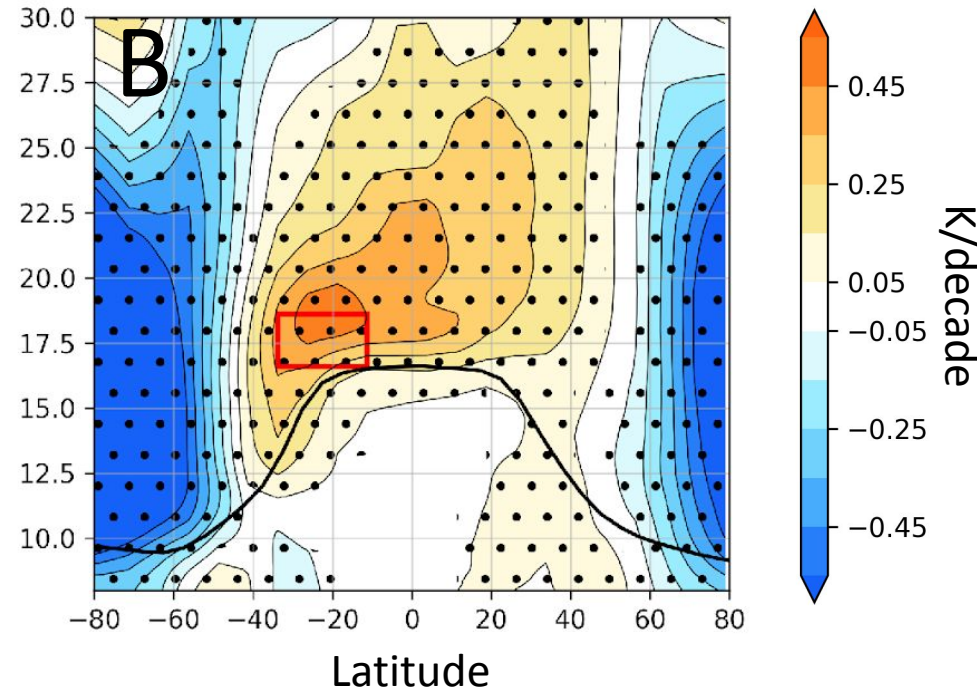
The trends associated with the  
AWLS have a dynamical signature

# The AWLS is dynamically induced

Temperature Trends  
(2002-2022)



Trends from  
Circulation Regression

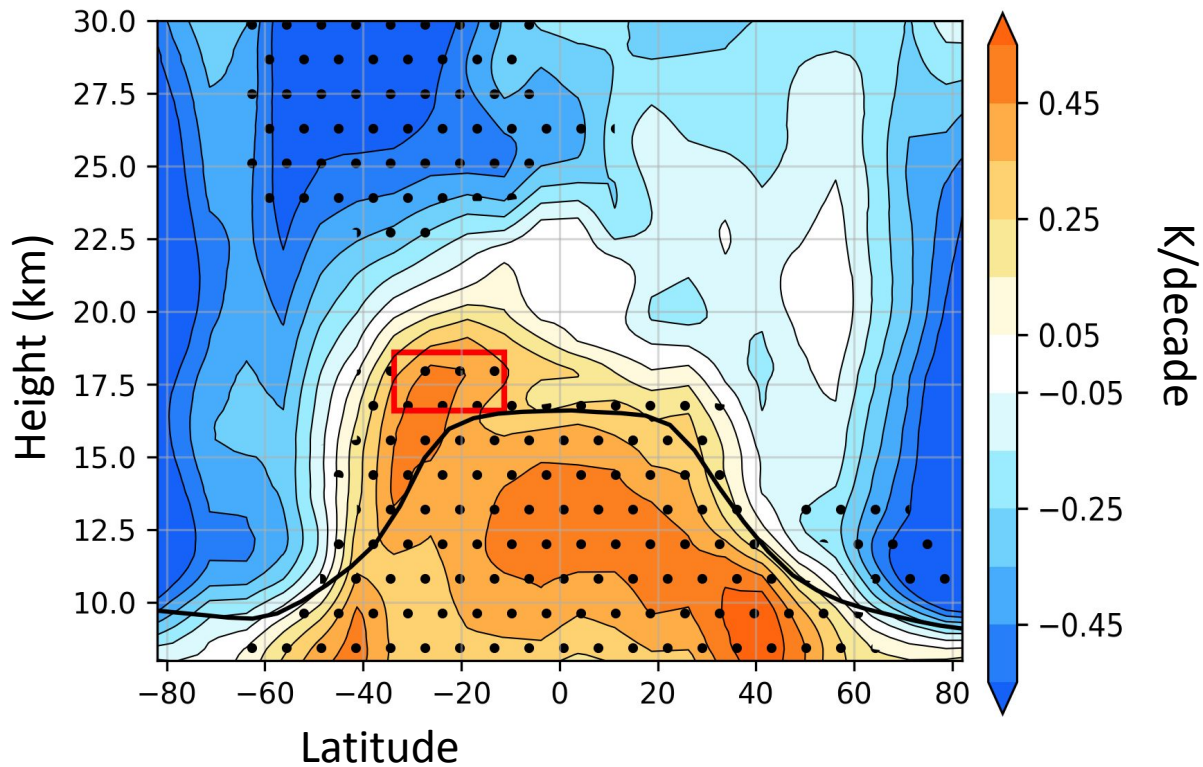


Radiation Model suggests composition changes alone would have *cooled* the AWLS region

The trends associated with the AWLS have a dynamical signature

# The Warming of the SH Subtropical Lower Stratosphere and Implications for detecting Antarctic Ozone Recovery

GNSS-RO Trends 2002-2022



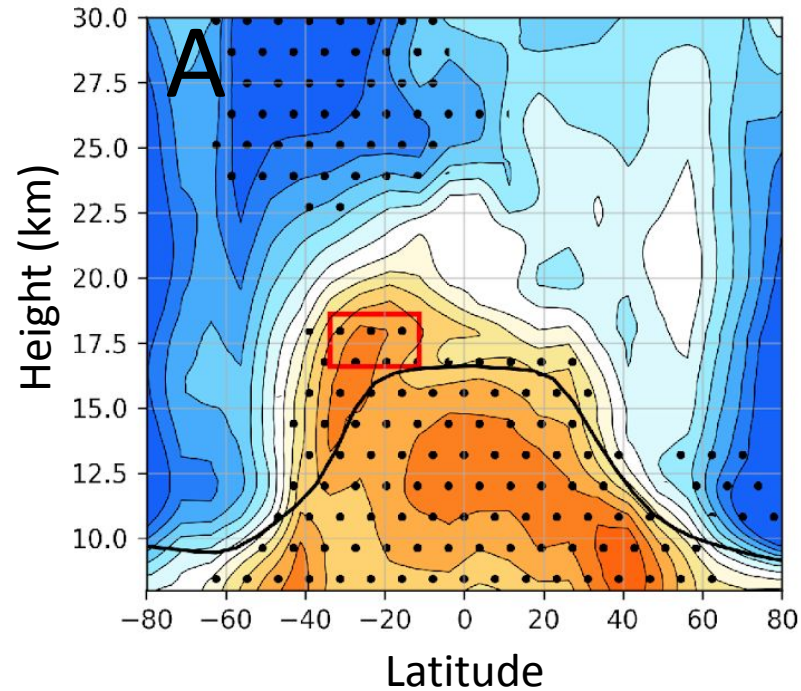
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1. The AWLS is dynamically induced
2. Dynamics mask signal of ozone recovery

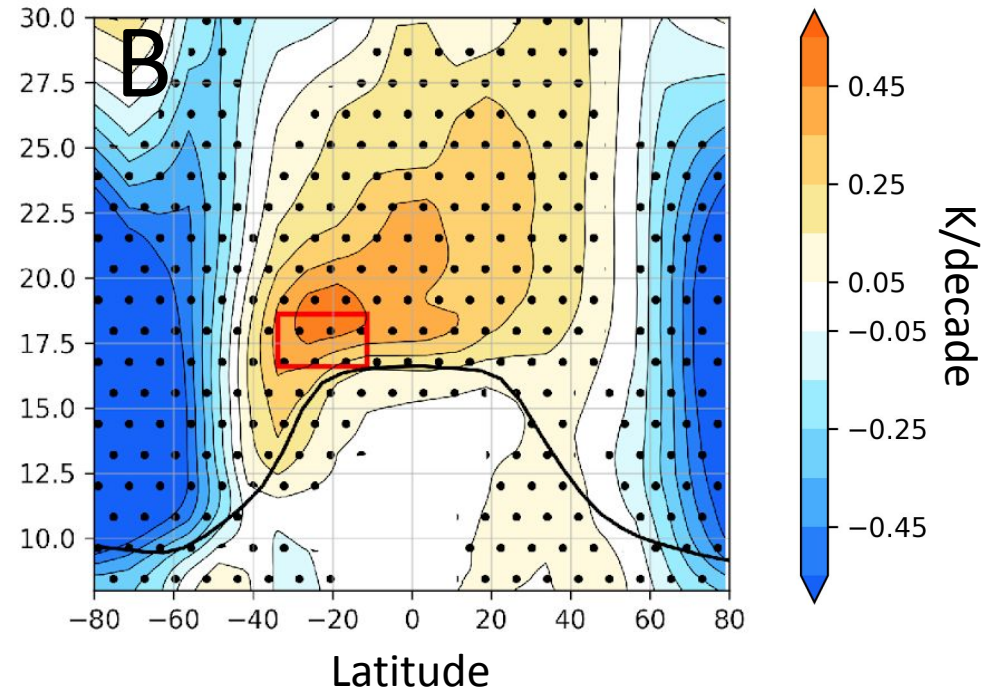


# Dynamics mask signal of ozone recovery

Temperature Trends  
(2002-2022)



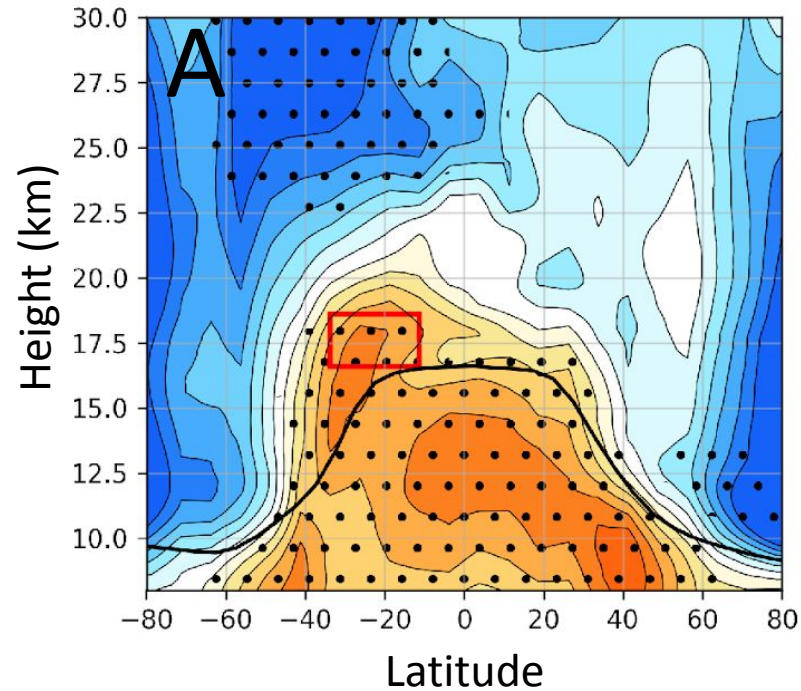
Trends from  
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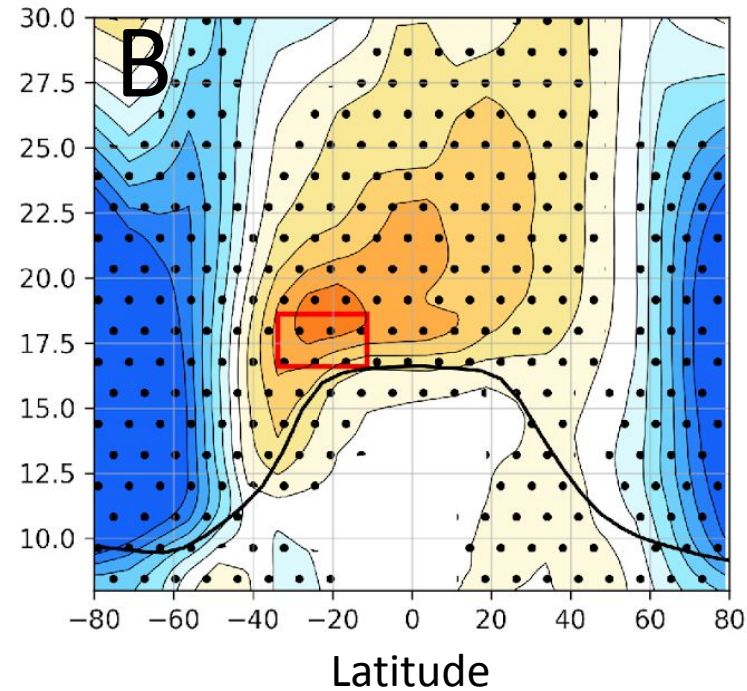
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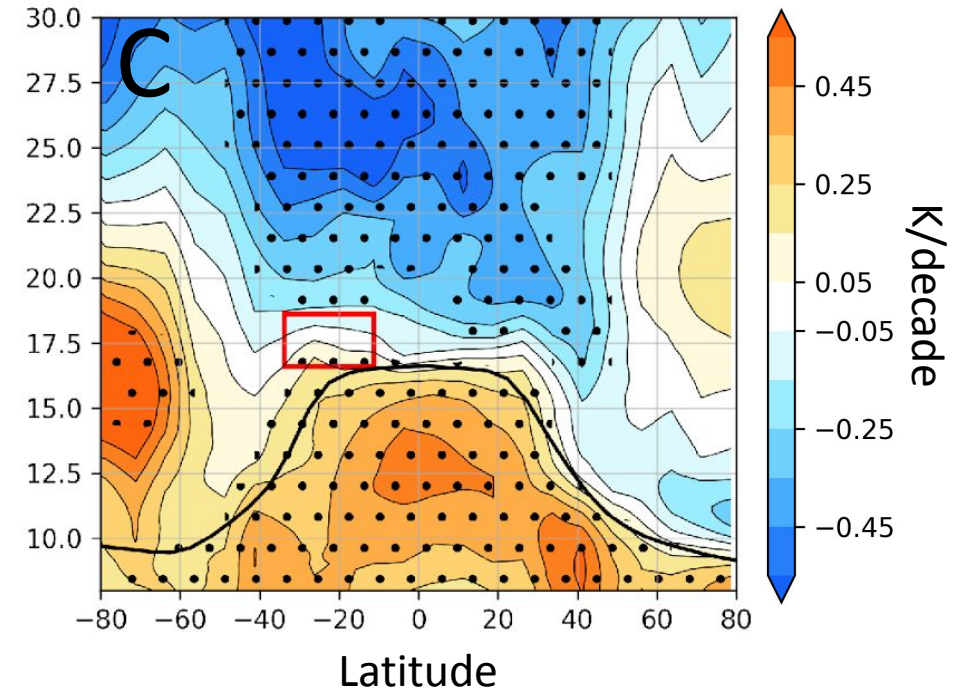
Temperature Trends  
(2002-2022)



Trends from  
Circulation Regression



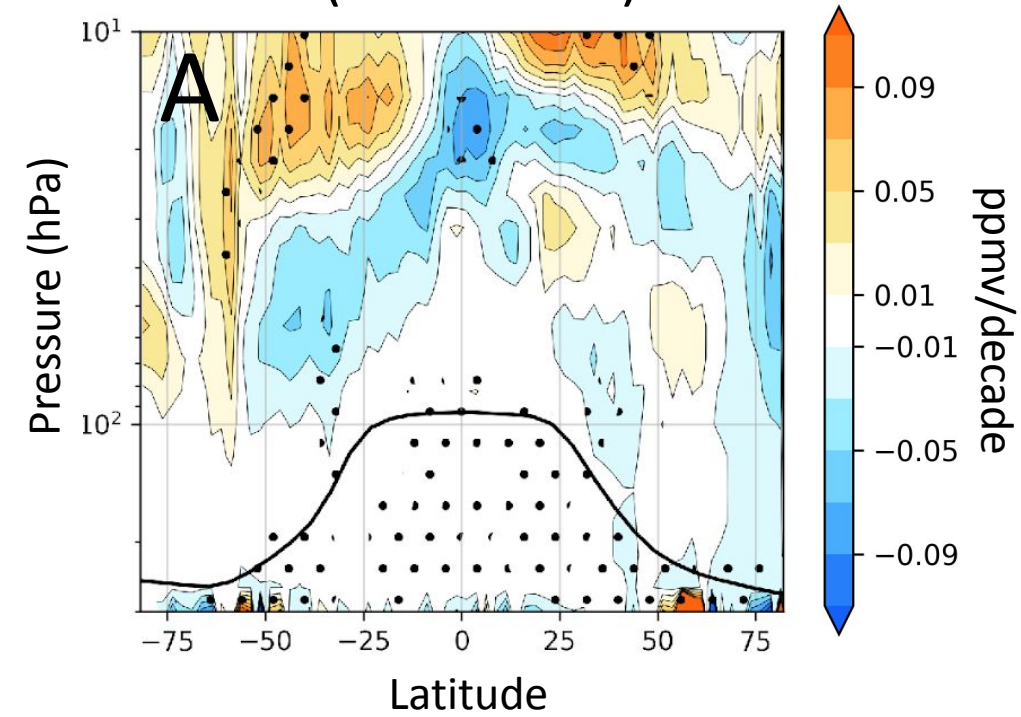
Difference



The Difference trends (C) have a radiative signature

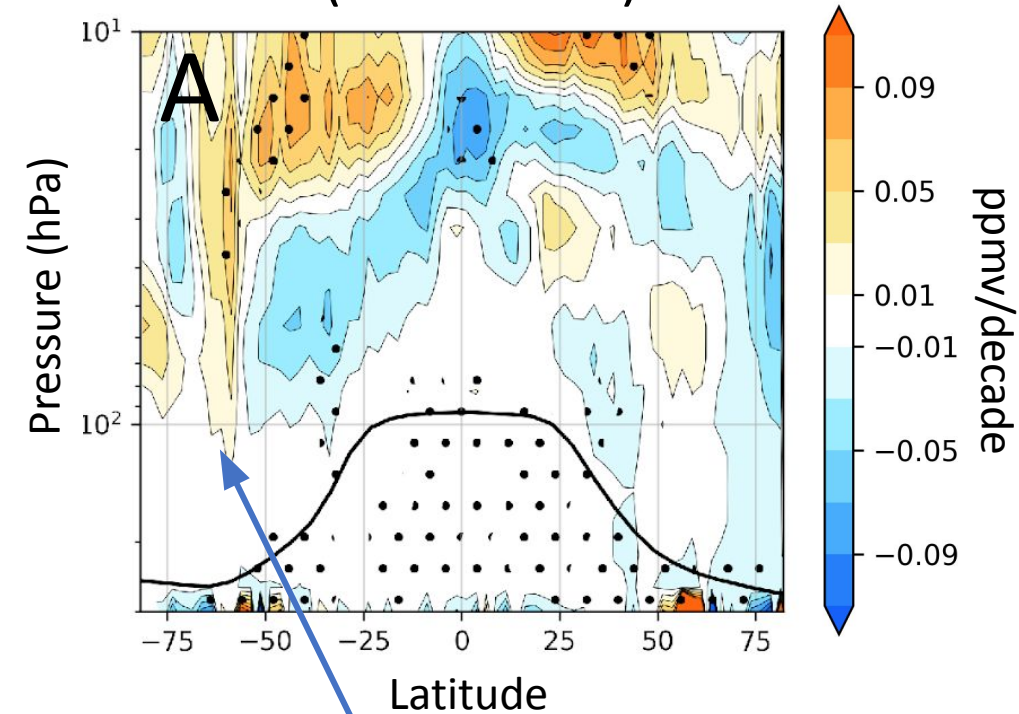
# Dynamics mask signal of ozone recovery

Ozone Trends SWOOSH  
(2002-2022)



# Dynamics mask signal of ozone recovery

Ozone Trends SWOOSH  
(2002-2022)

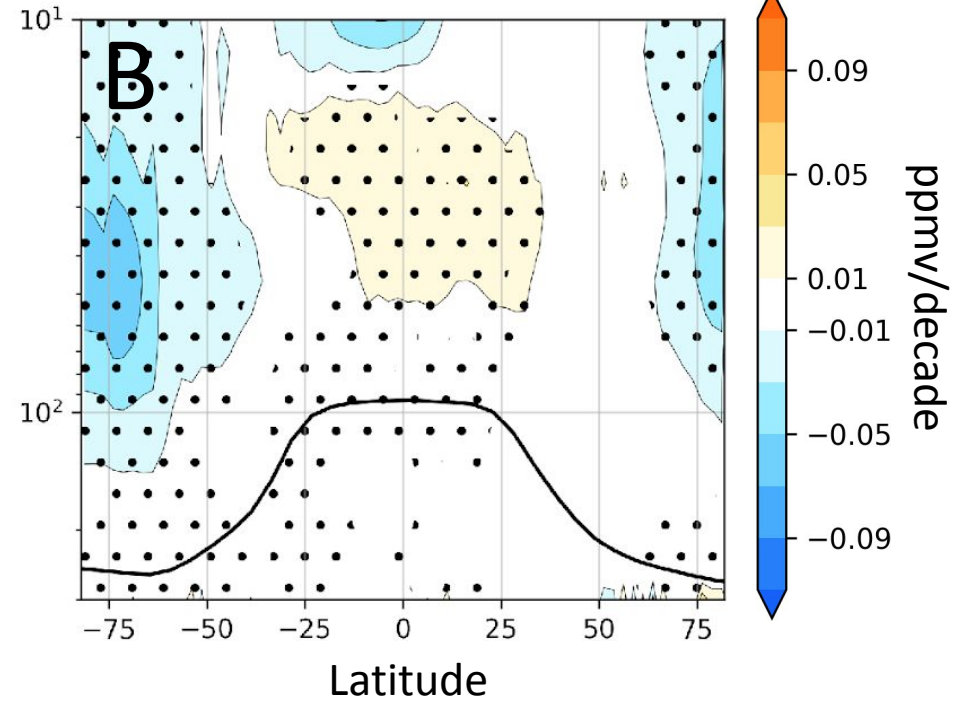
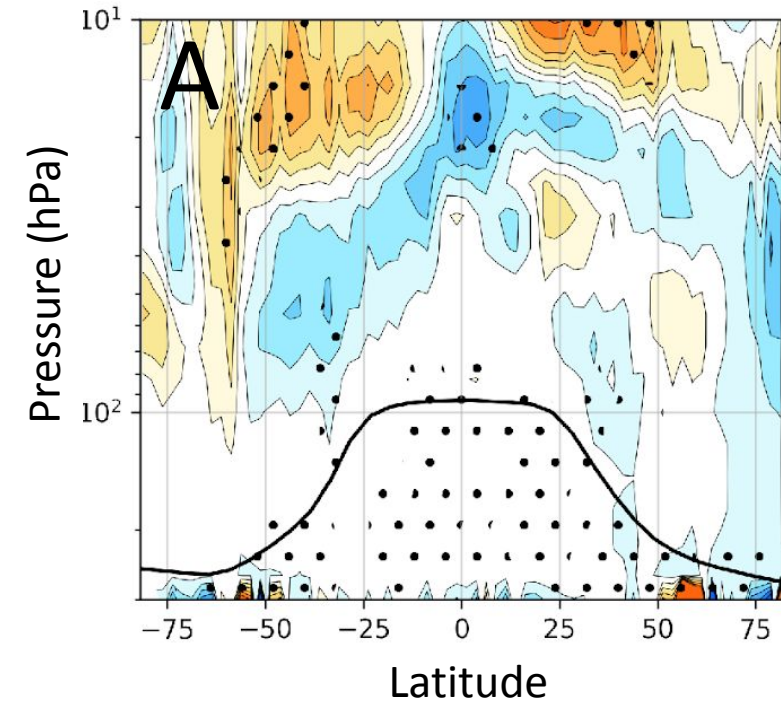


Observations do not show an obvious Antarctic ozone recovery

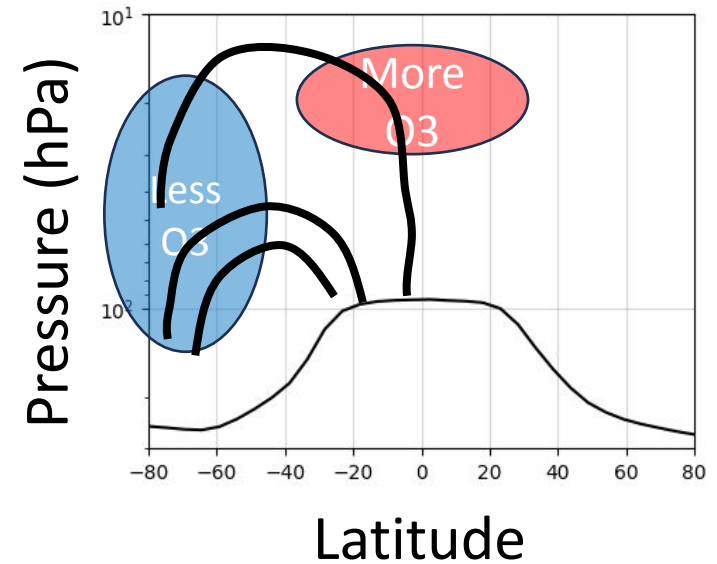
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Ozone Trends SWOOSH  
(2002-2022)

Trends from  
Circulation Regression



**Weakened Southern Hemisphere  
Stratospheric Circulation**

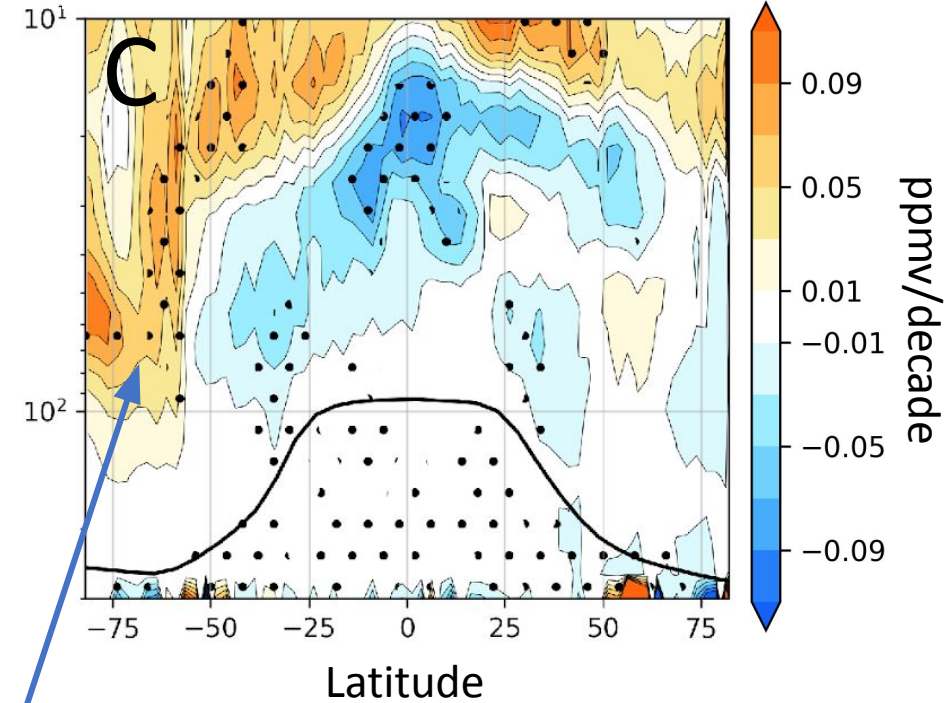
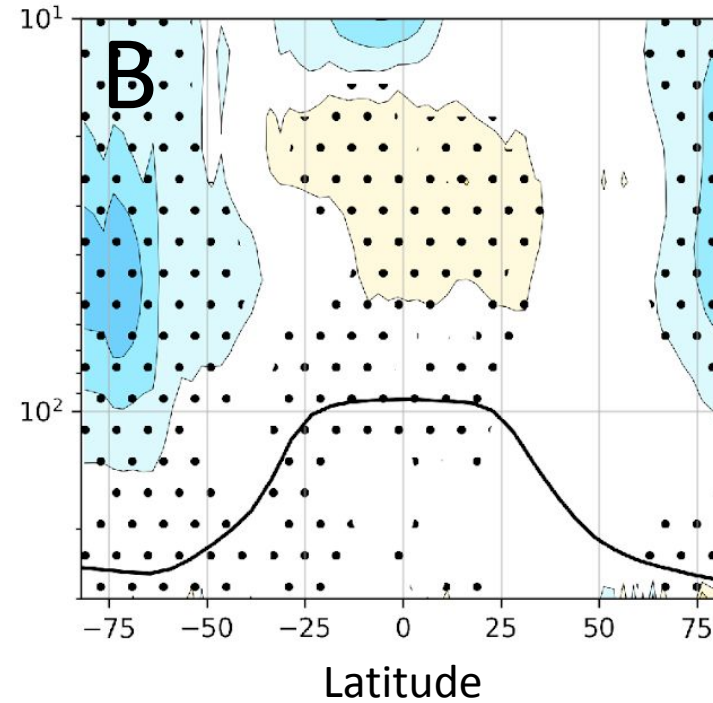
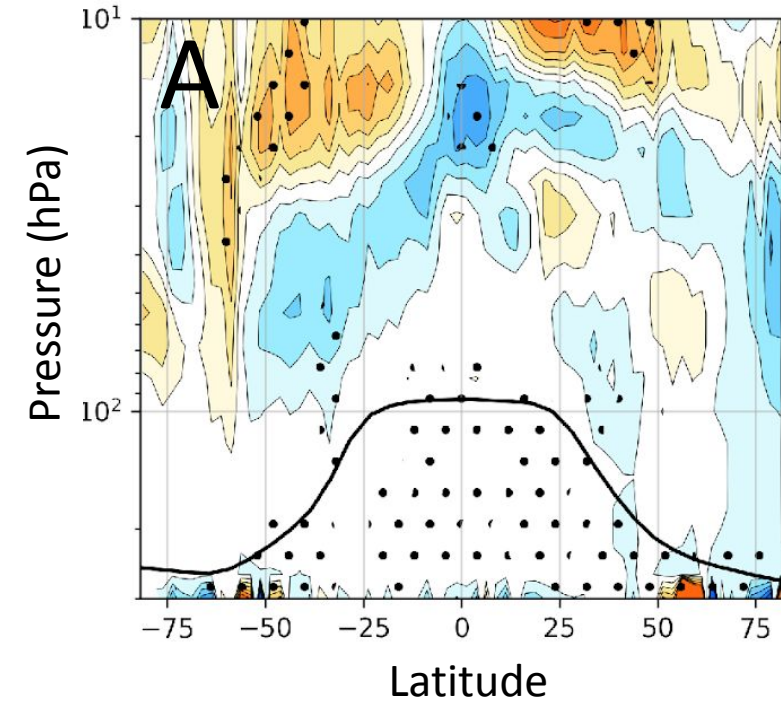


# Dynamics mask signal of ozone recovery

Ozone Trends SWOOSH  
(2002-2022)

Trends from  
Circulation Regression

Difference



Removing dynamical processes reveals an Antarctic ozone recovery

# The Anomalous Warming of the SH Subtropical Lower Stratosphere and Implications for Detecting Antarctic Ozone Recovery

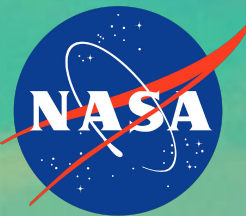
Aodhan Sweeney

COSMIC/JCSDA IROWG-10

September 17th, 2024

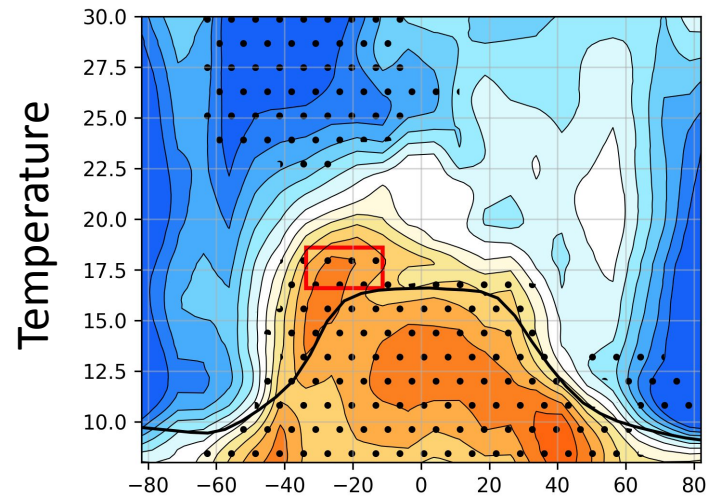
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  - A stratospheric circulation slowdown weakens poleward transport of ozone rich air

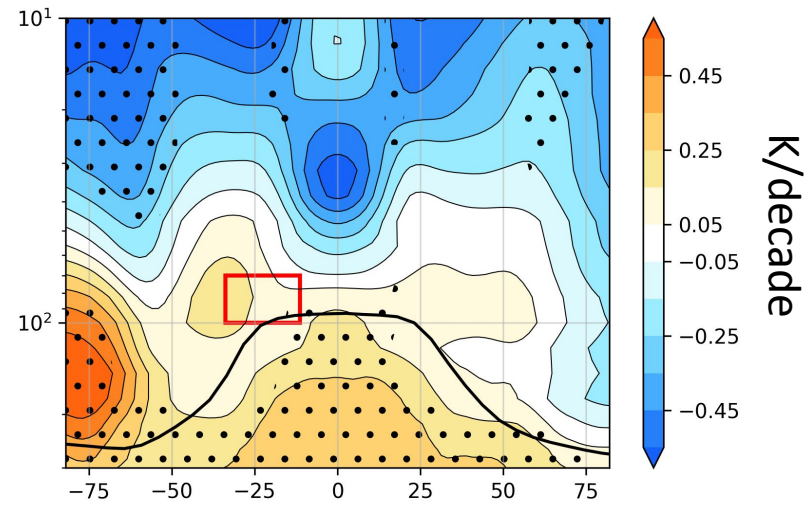


# Dynamics mask signal of ozone recovery

Temperature  
Trends



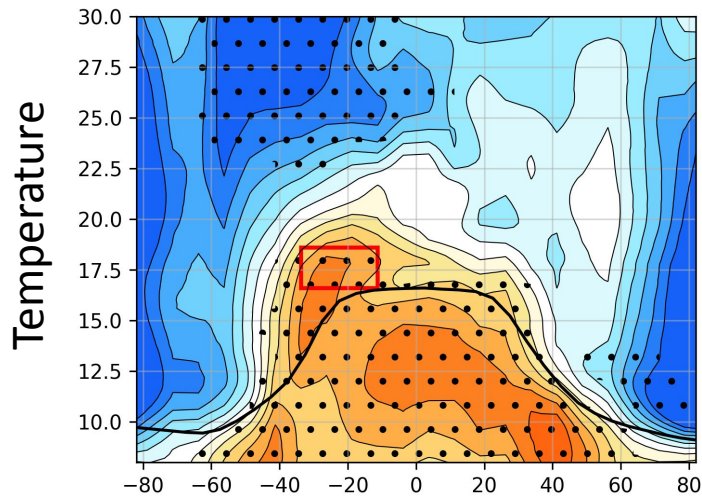
WACCM Ensemble Mean



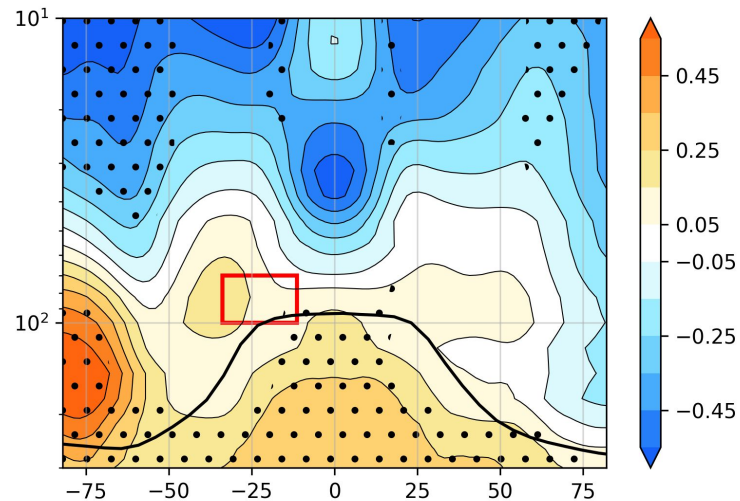


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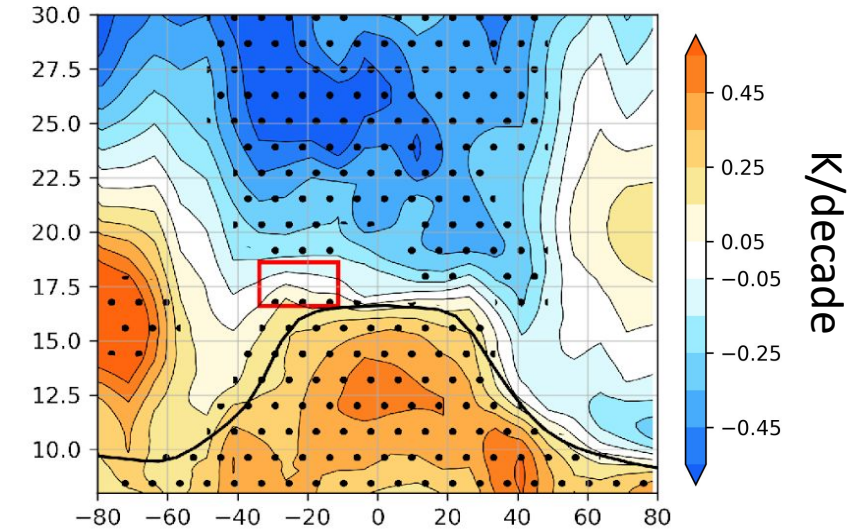
GNSS-RO



WACCM Ensemble Mean



GNSS-RO Minus Dynamics



Removing dynamical trends leads to closer agreement between observations and models

# The Anomalous Warming of the SH Subtropical Lower Stratosphere and Implications for Detecting Antarctic Ozone Recovery

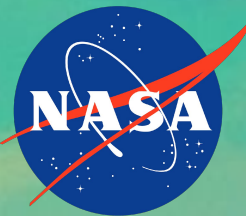
Aodhan Sweeney

COSMIC/JCSDA IROWG-10

September 17th, 2024

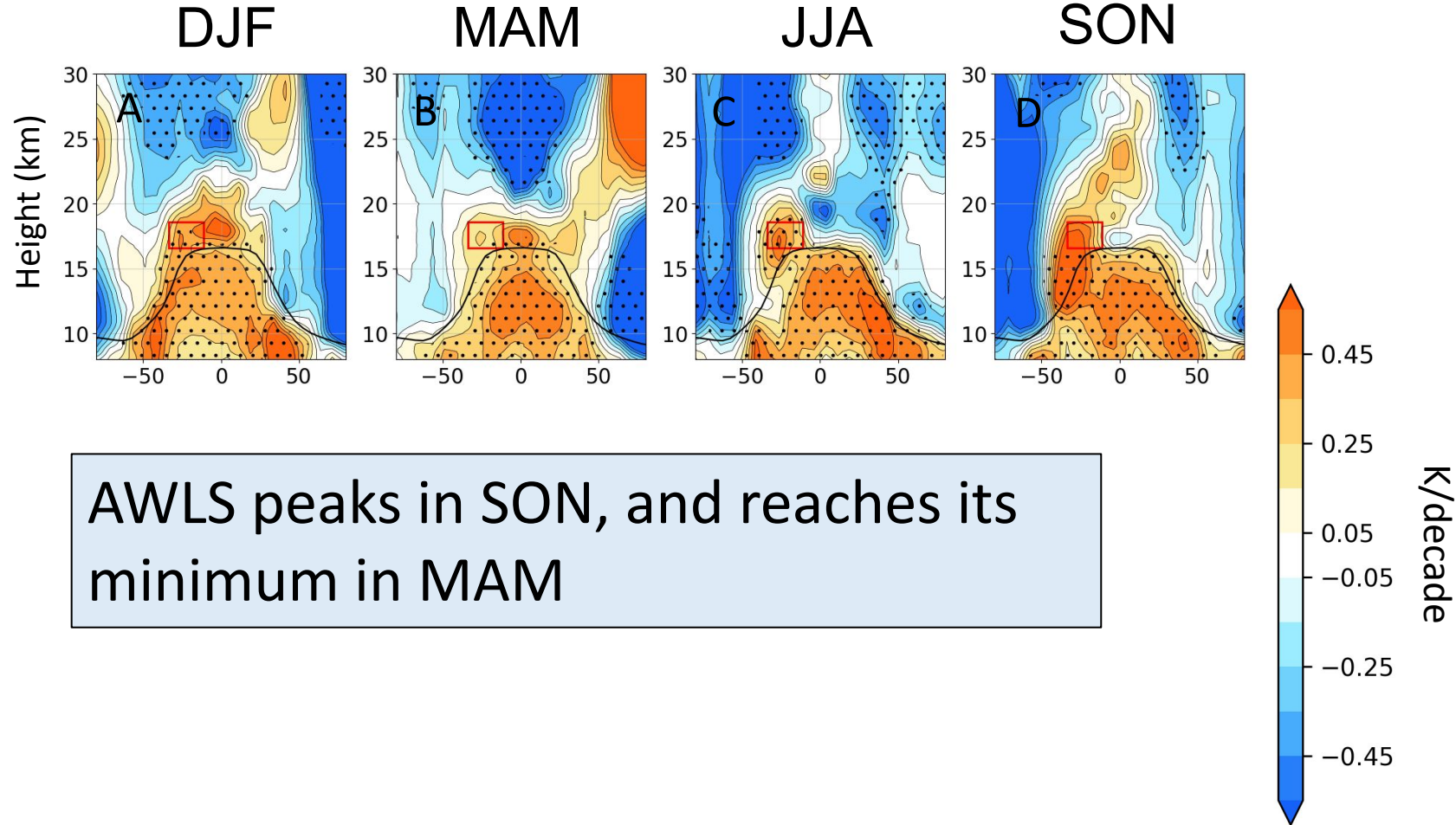
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# Dynamics mask signal of ozone recovery

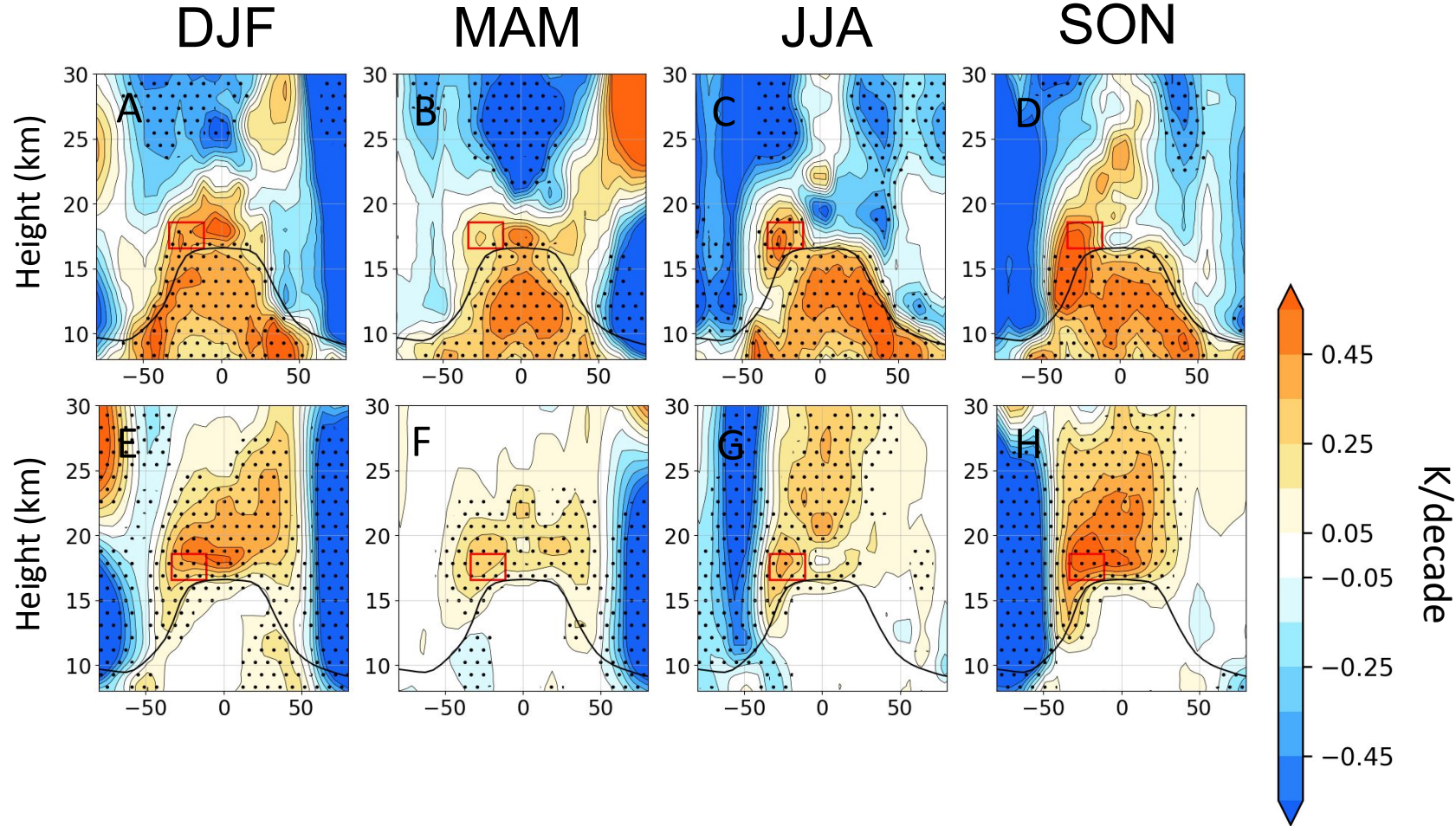
Temperature  
Trends



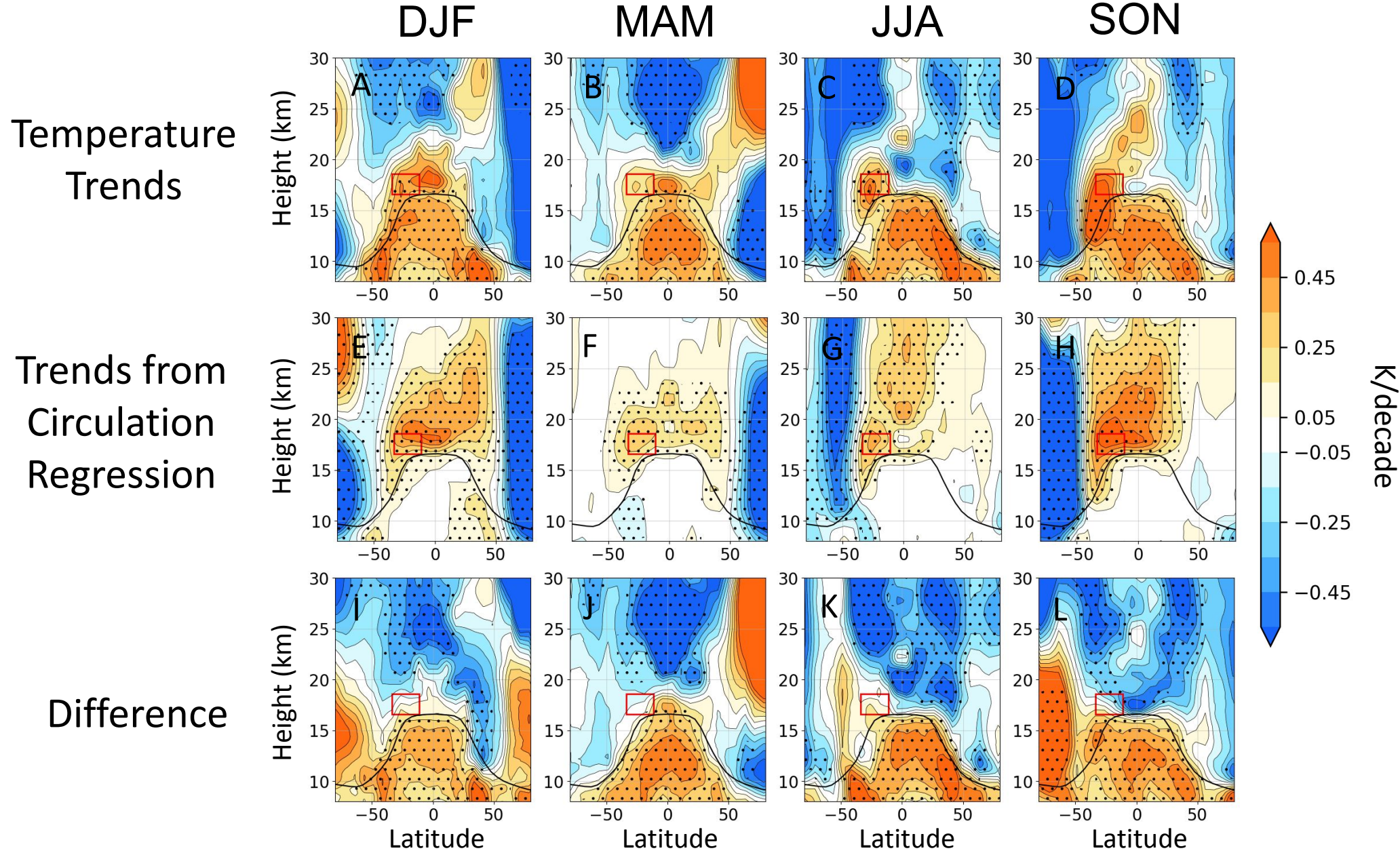
# Dynamics mask signal of ozone recovery

Temperature Trends

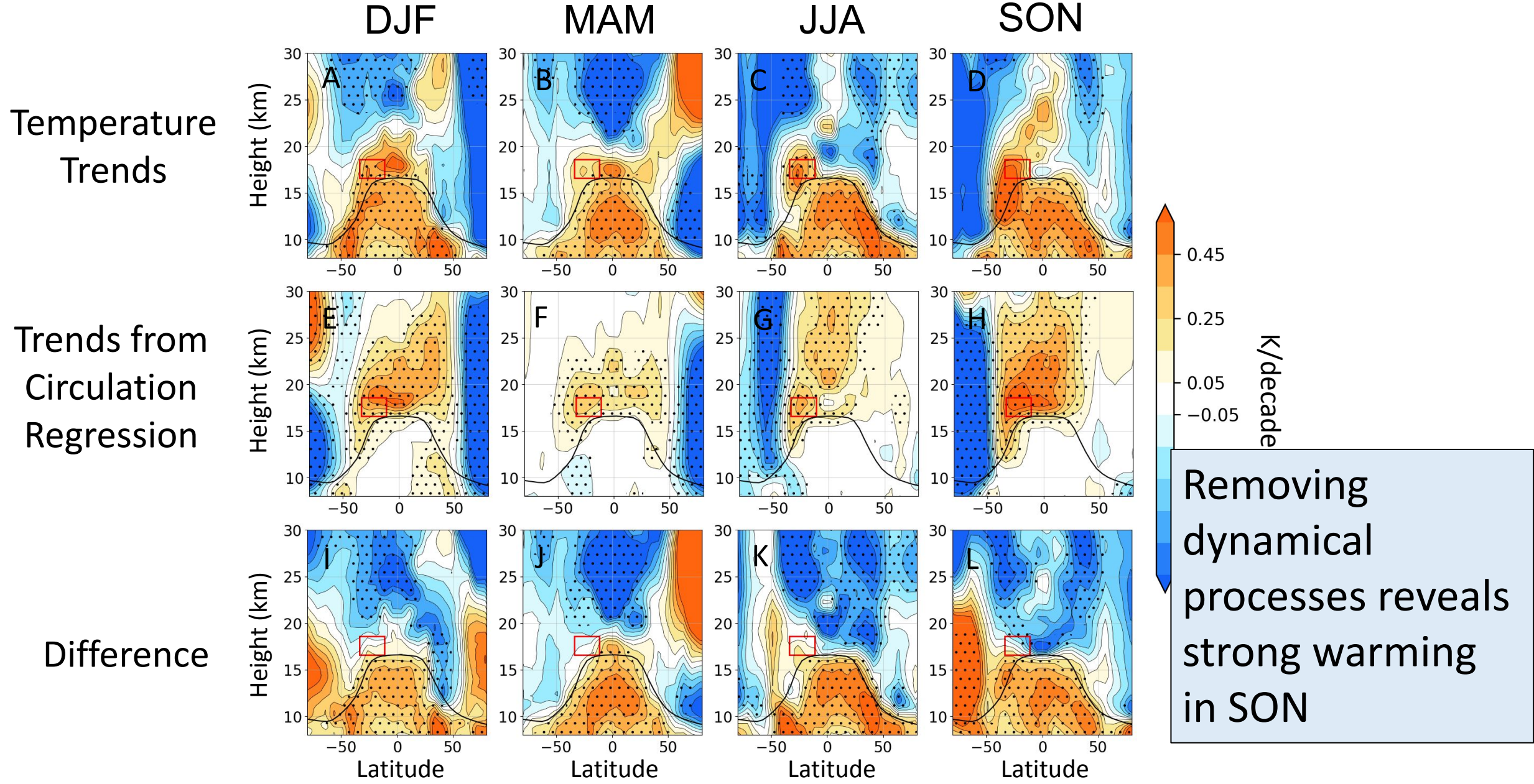
Trends from Circulation Regression



# Dynamics mask signal of ozone recovery

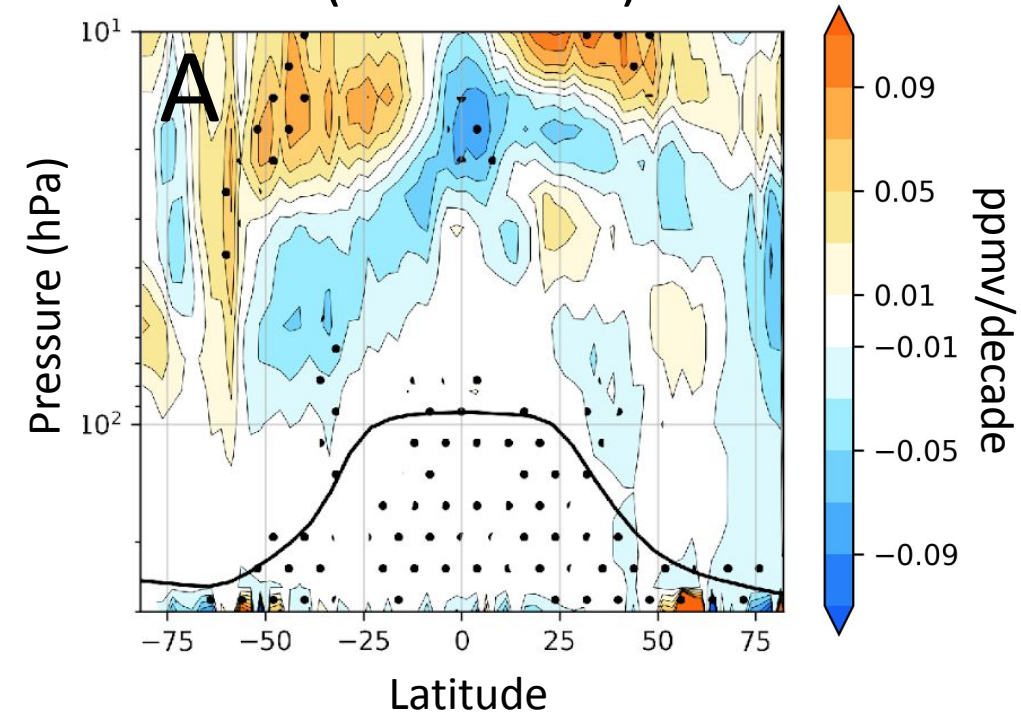


# Dynamics mask signal of ozone recovery



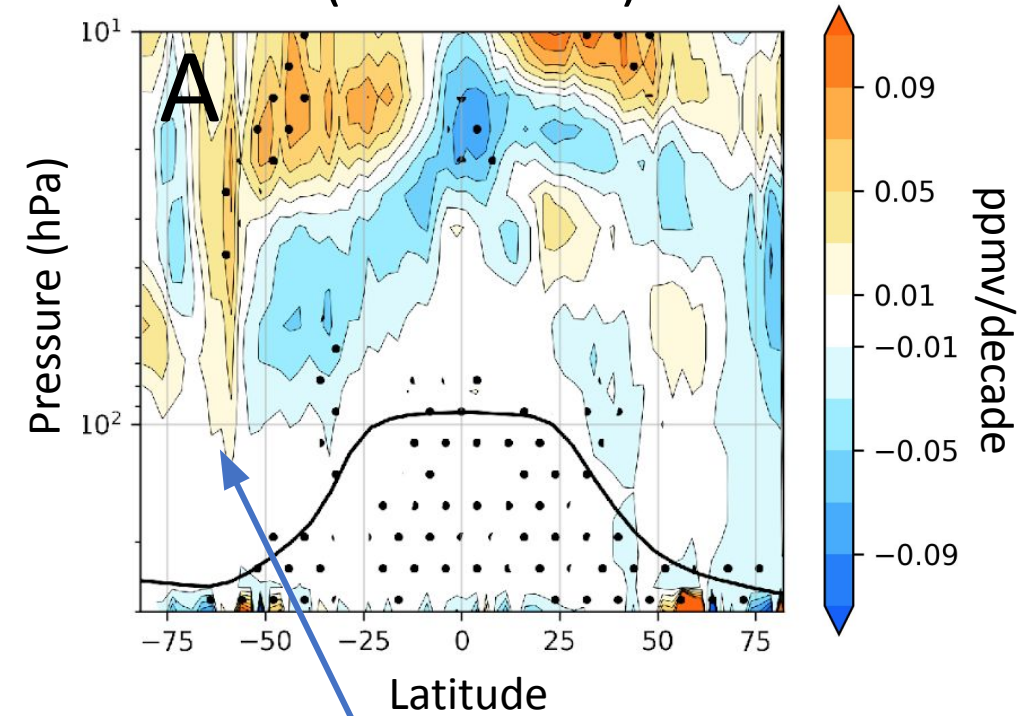
# Dynamics mask signal of ozone recovery

Ozone Trends SWOOSH  
(2002-2022)



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Ozone Trends SWOOSH  
(2002-2022)

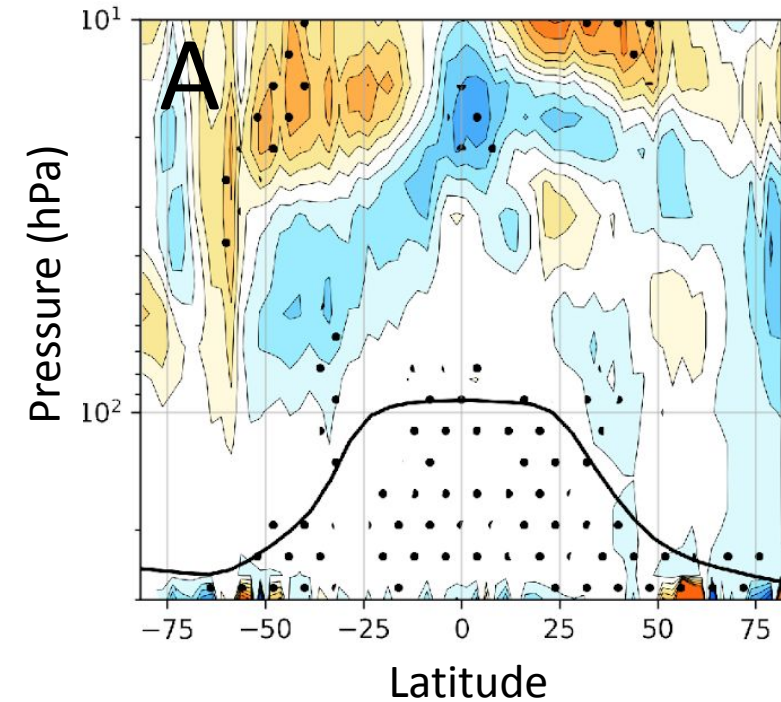


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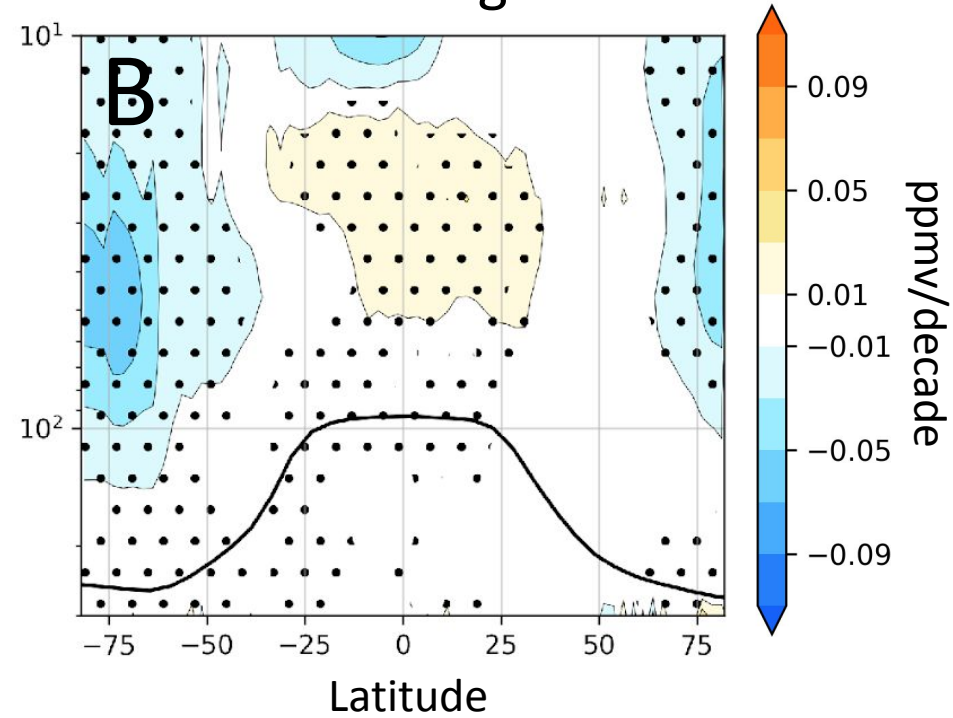


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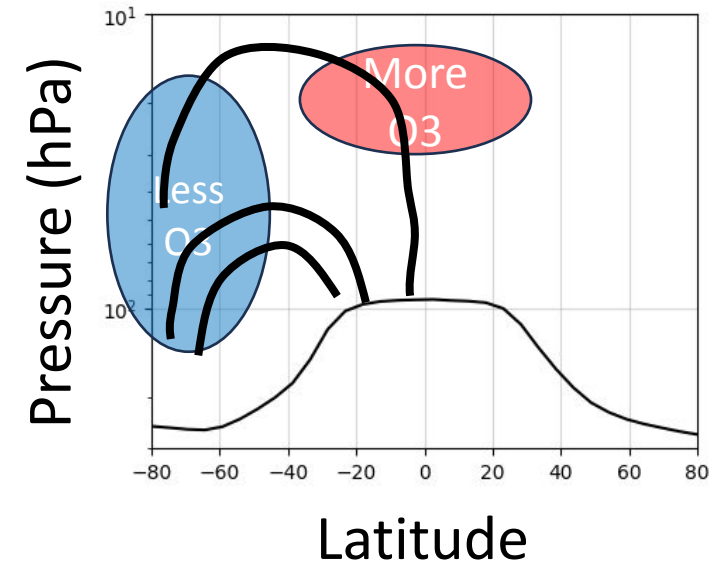
Ozone Trends SWOOSH  
(2002-2022)



Trends from  
Circulation Regression

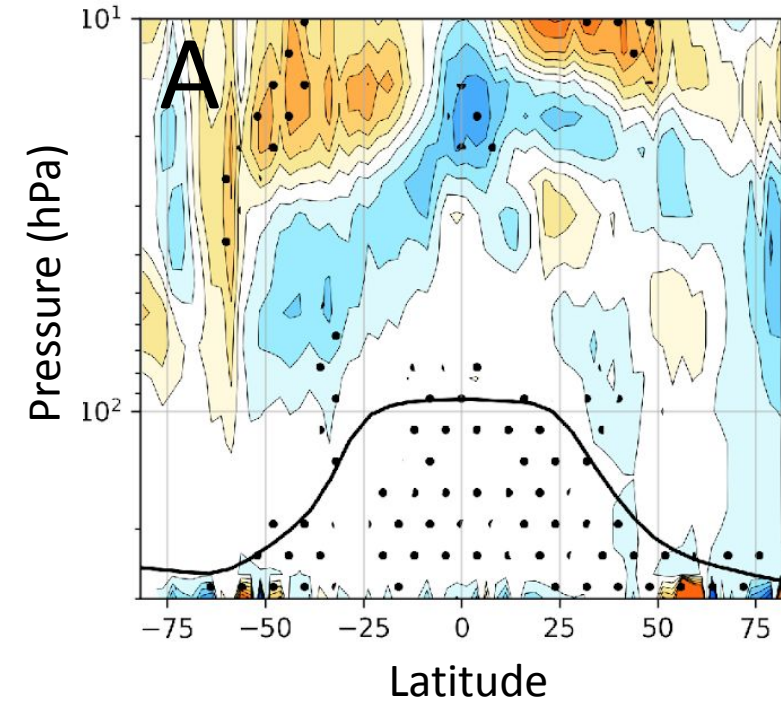


**Weakened Southern  
Hemisphere  
Stratospheric Circulation**

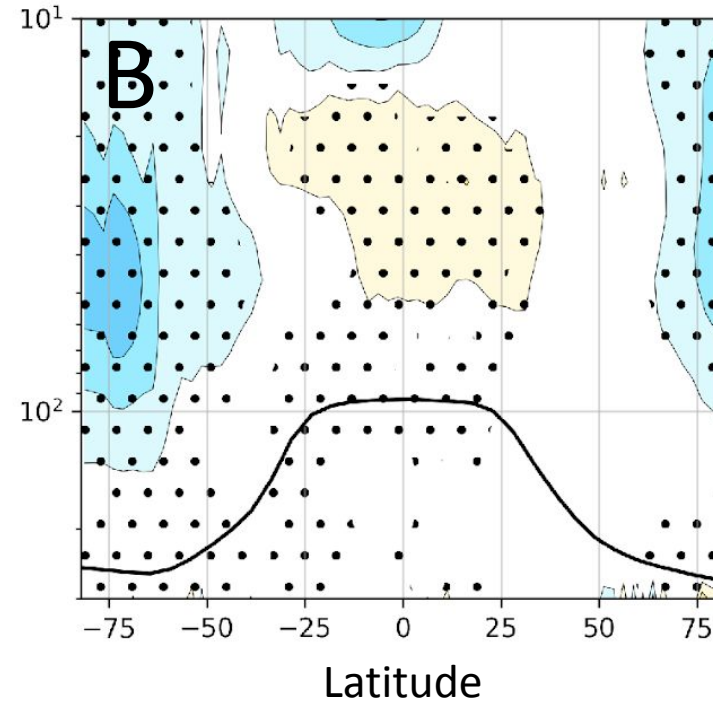


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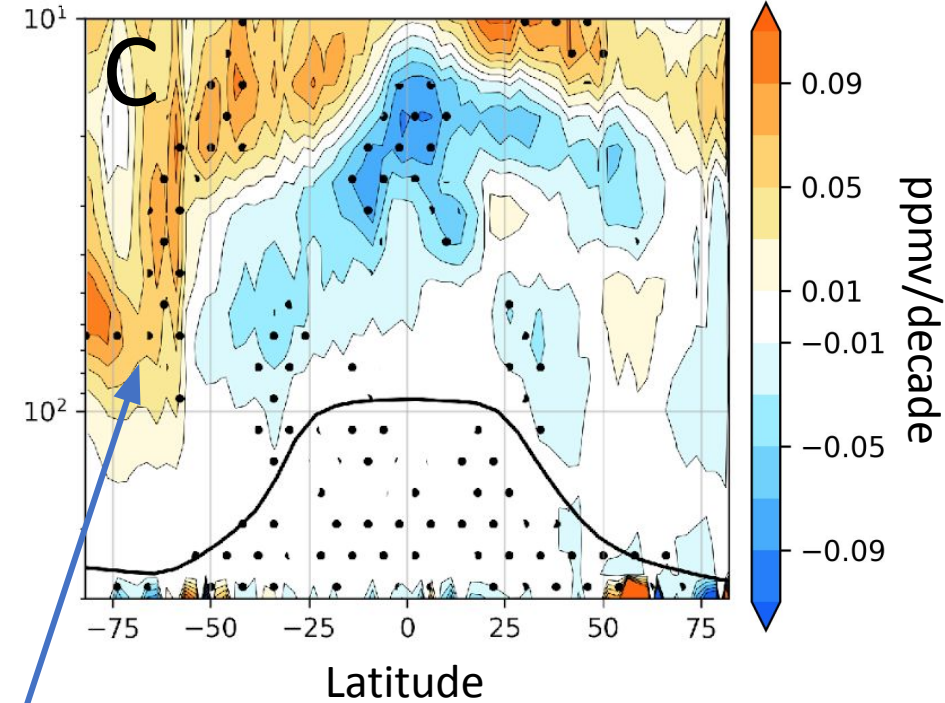
Ozone Trends SWOOSH  
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Trends from  
Circulation Regression



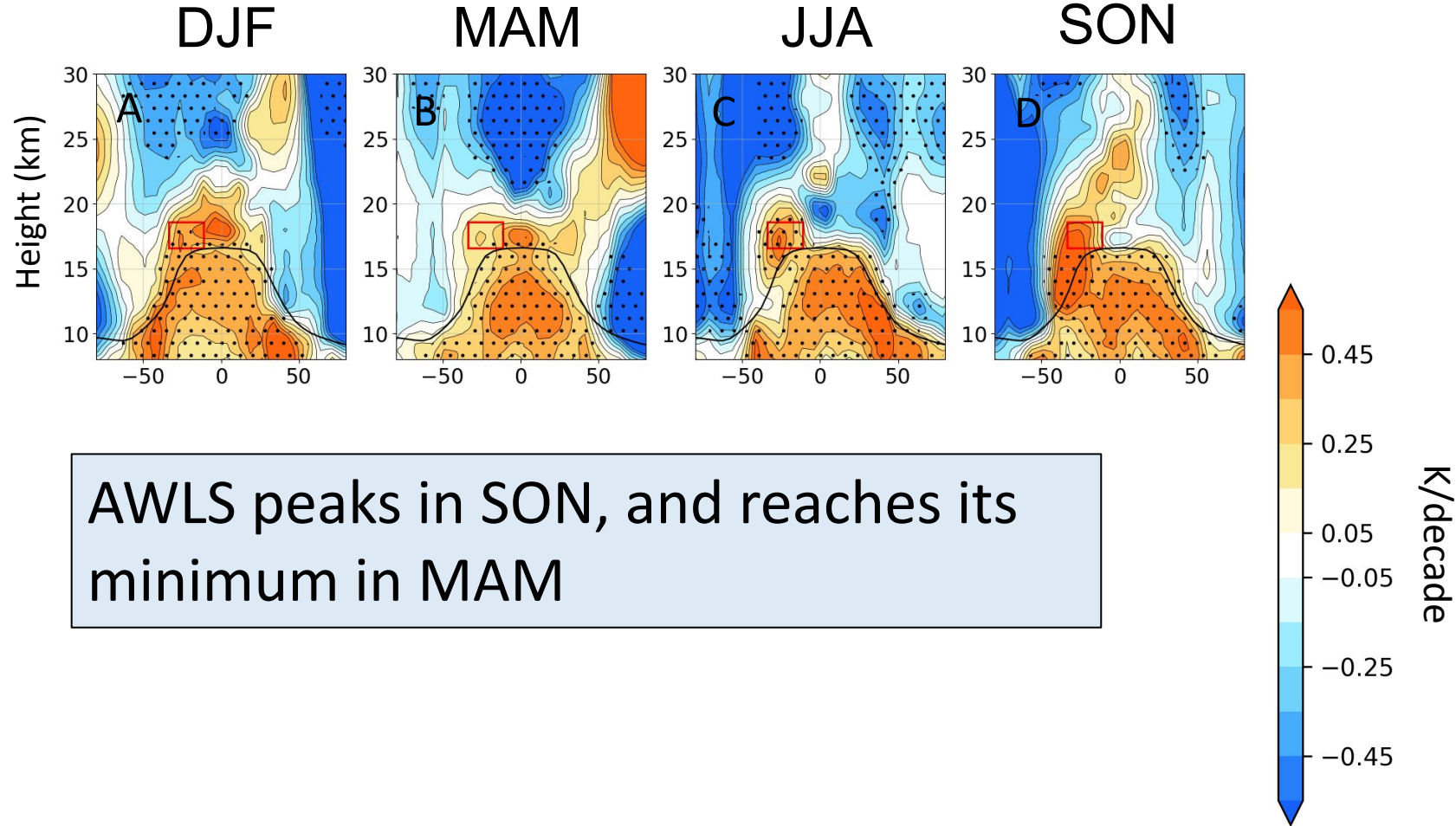
Difference



Removing dynamical processes reveals an Antarctic ozone recovery

# Dynamics mask signal of ozone recovery

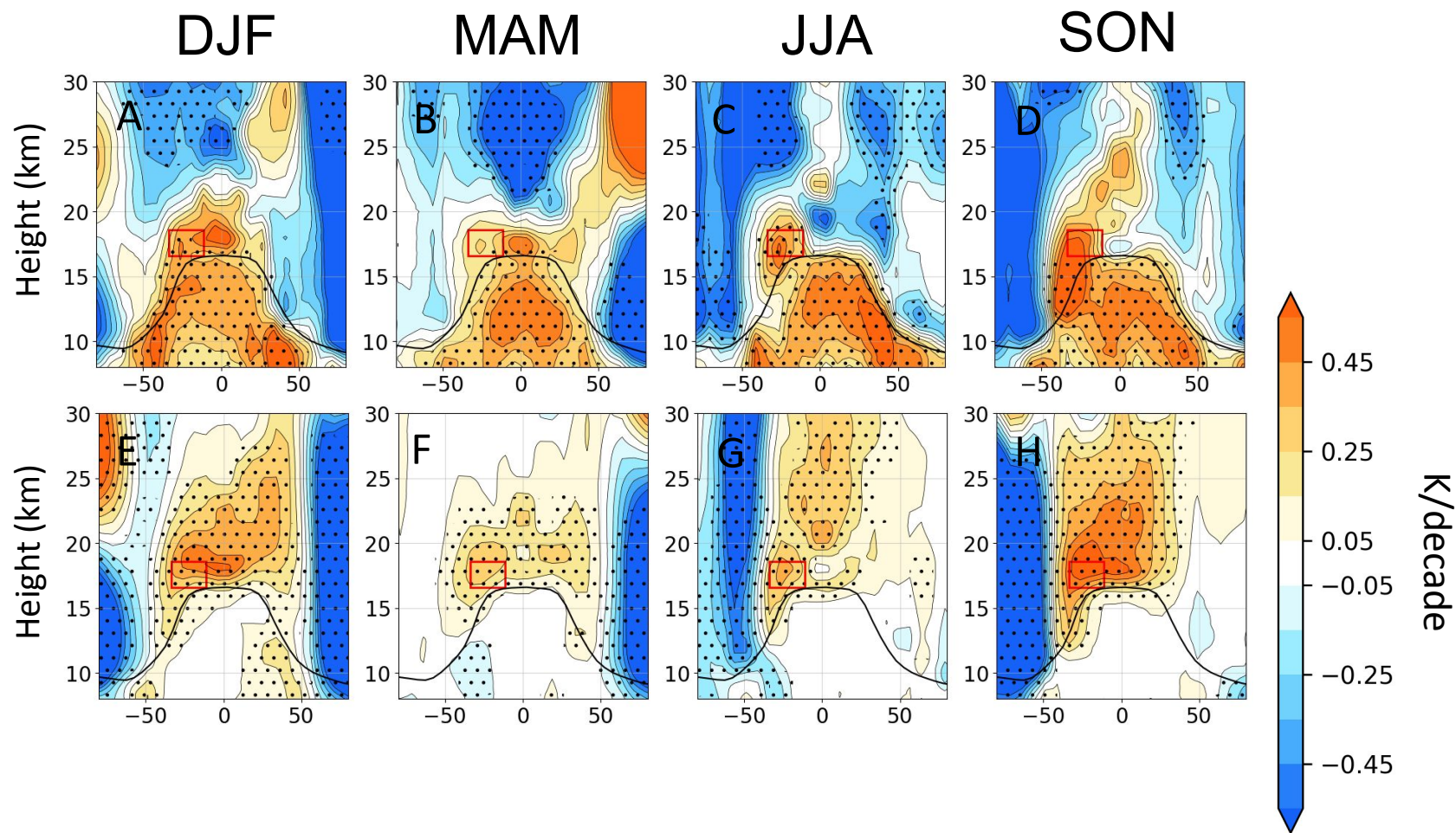
Temperature  
Trends



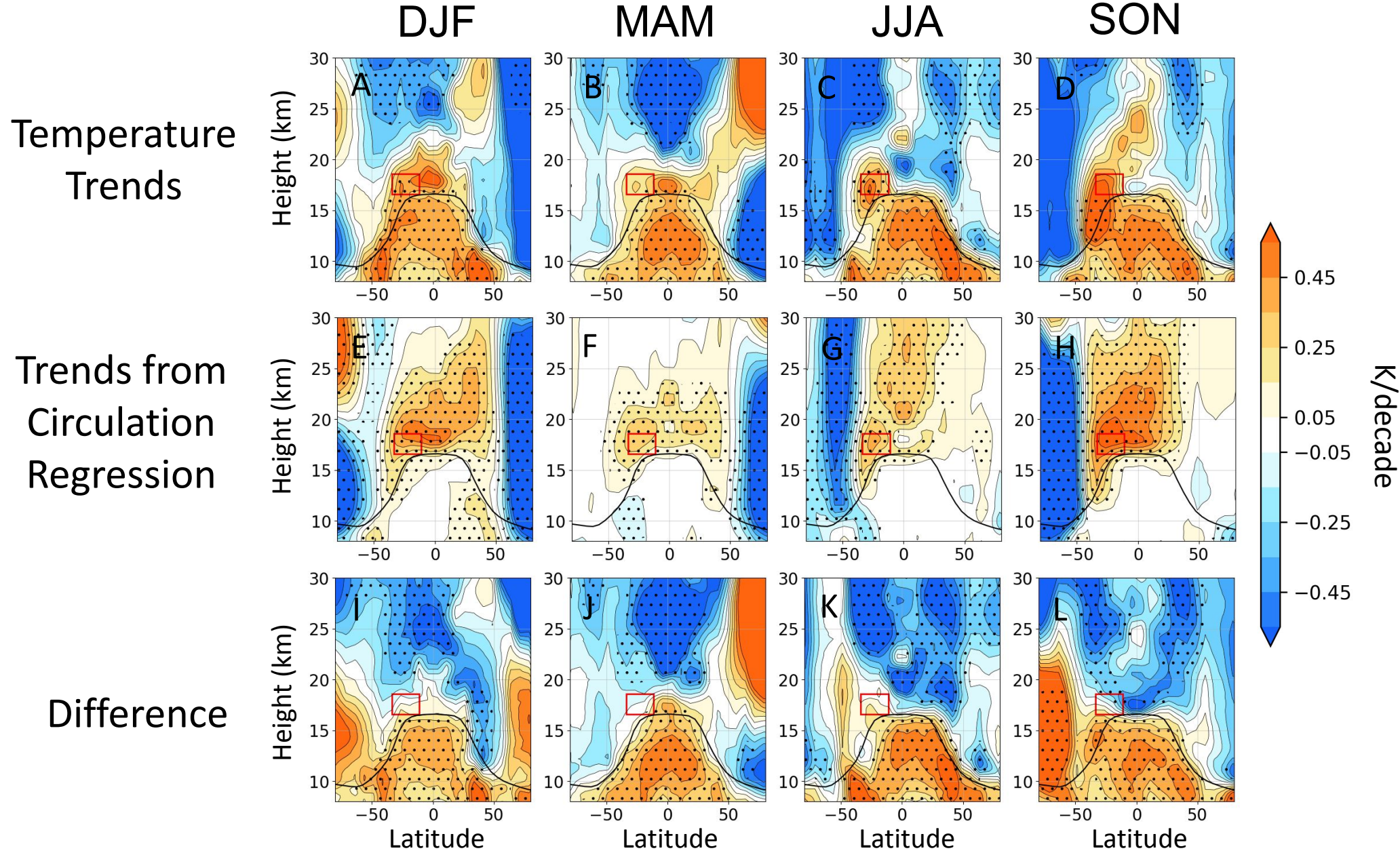
# Dynamics mask signal of ozone recovery

Temperature Trends

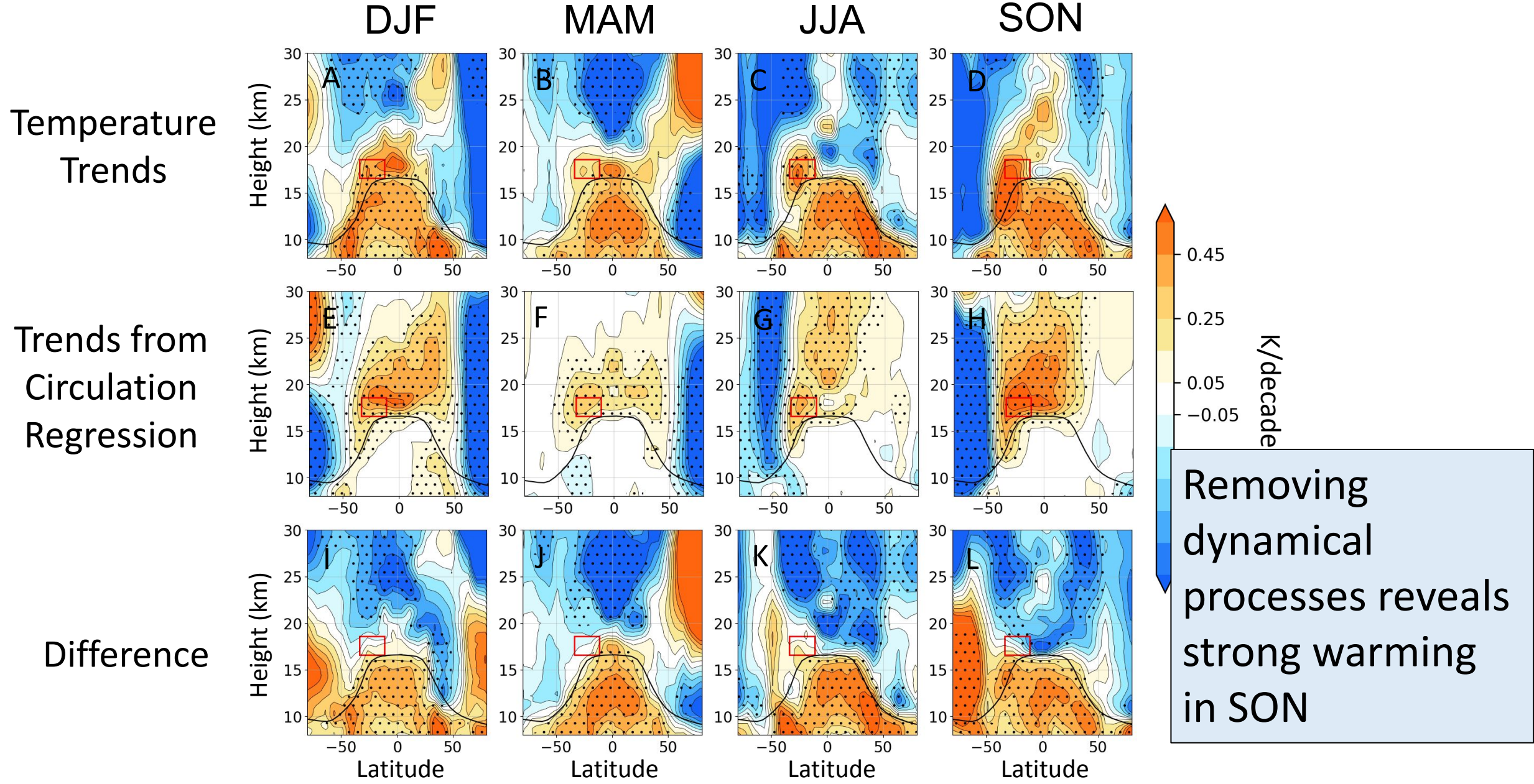
Trends from Circulation Regression



# Dynamics mask signal of ozone recovery

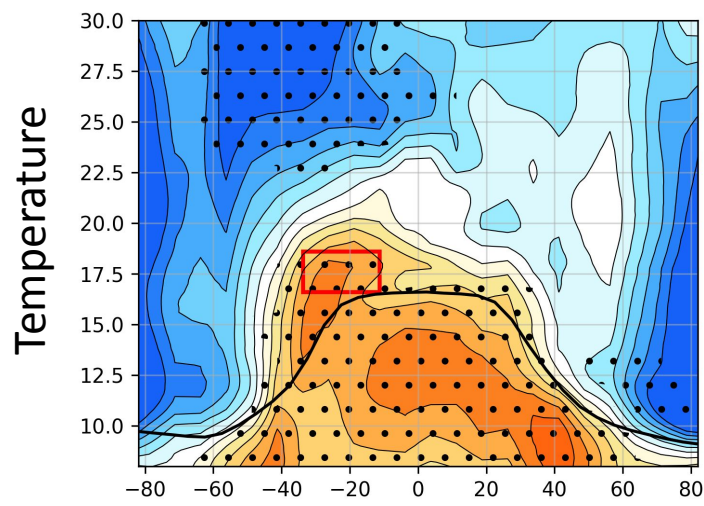


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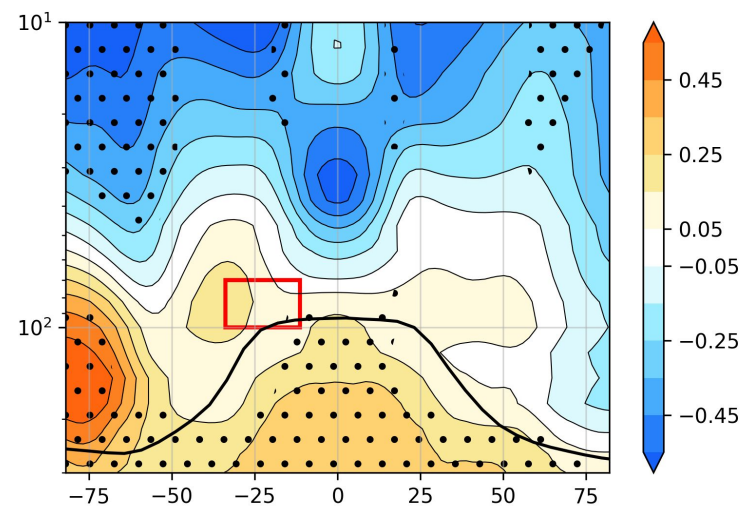


# Dynamics mask signal of ozone recovery

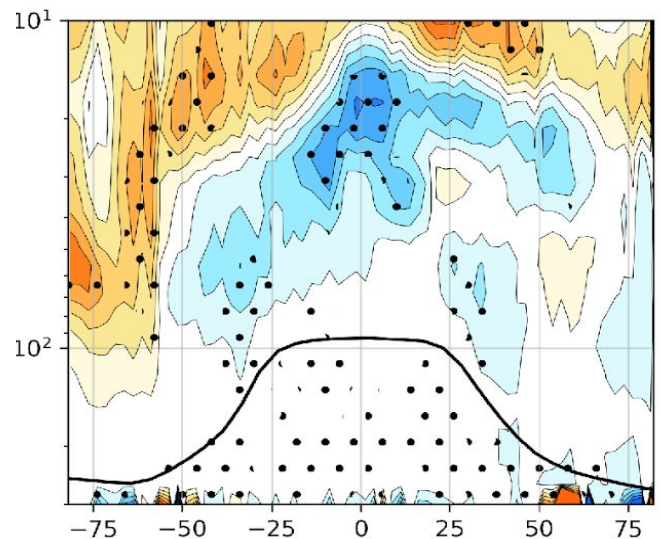
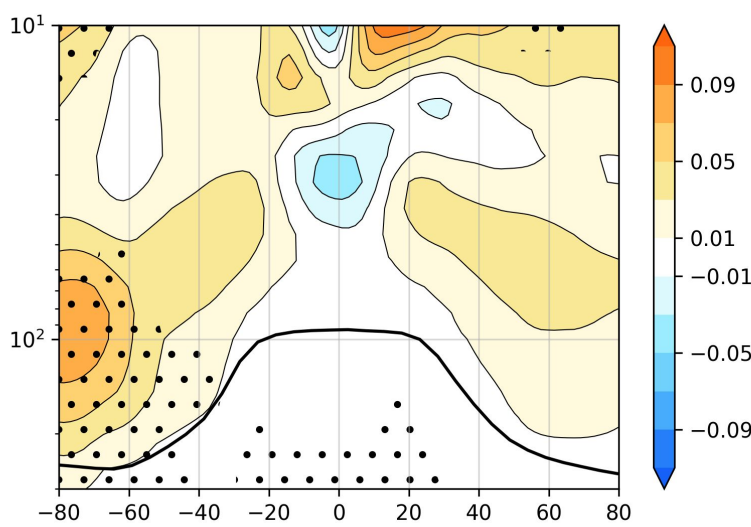
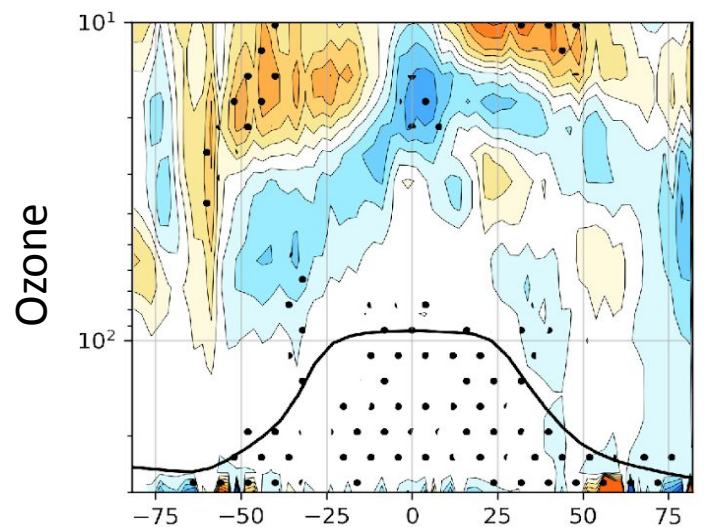
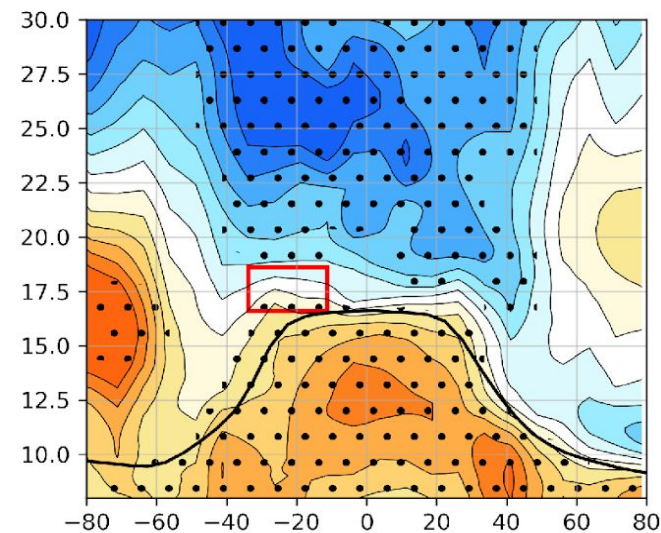
## Observations



## WACCM Ensemble Mean

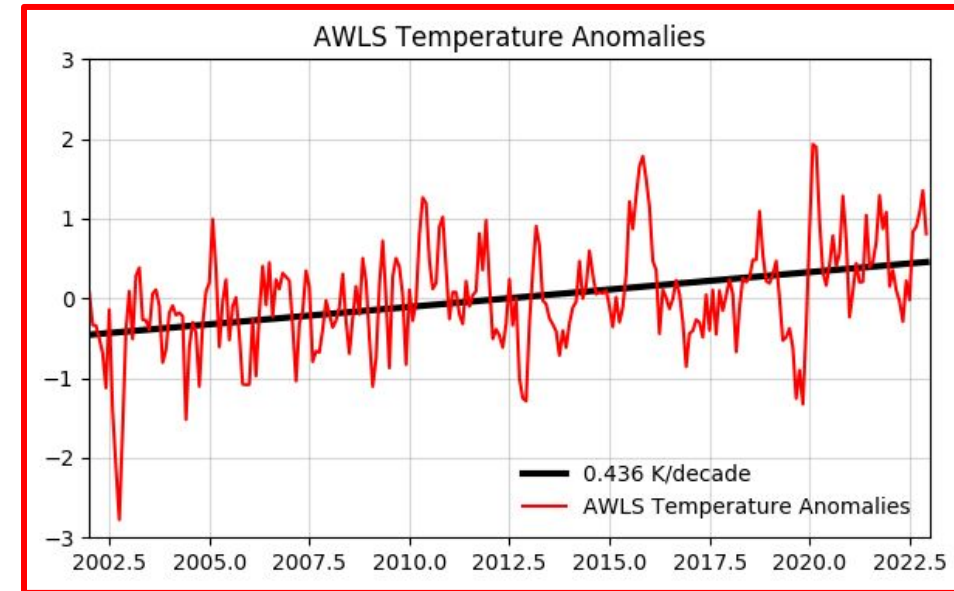
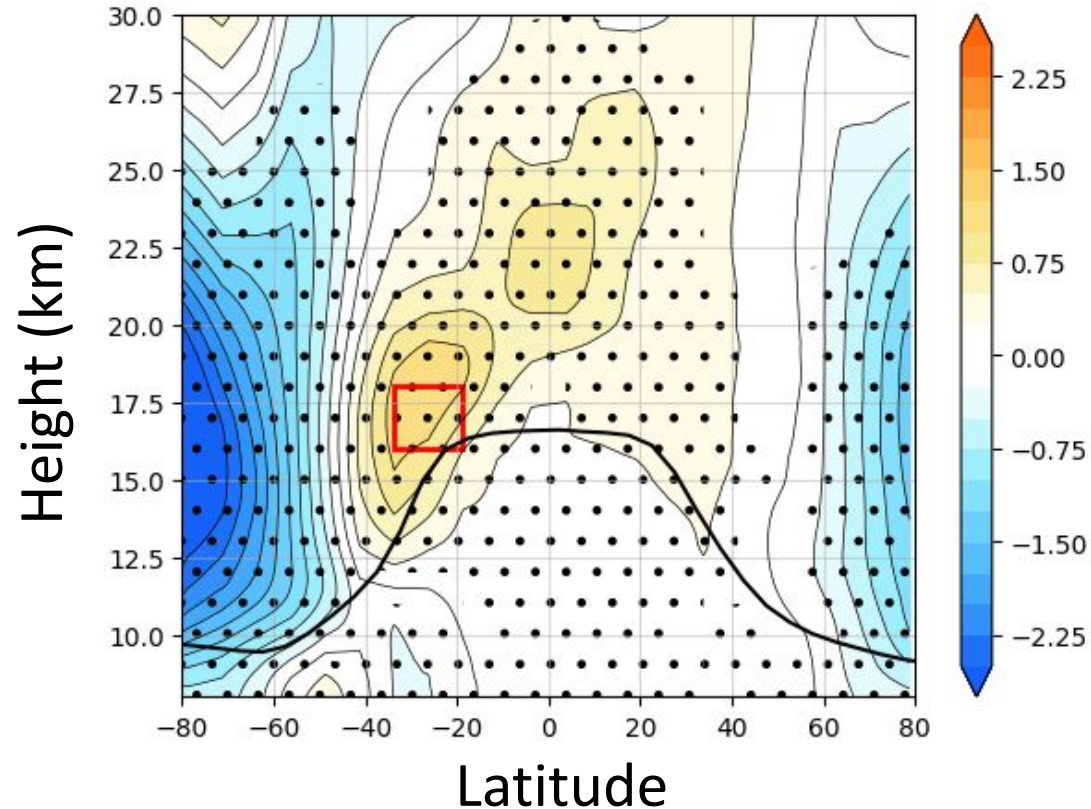


## Observations Minus Dynamics

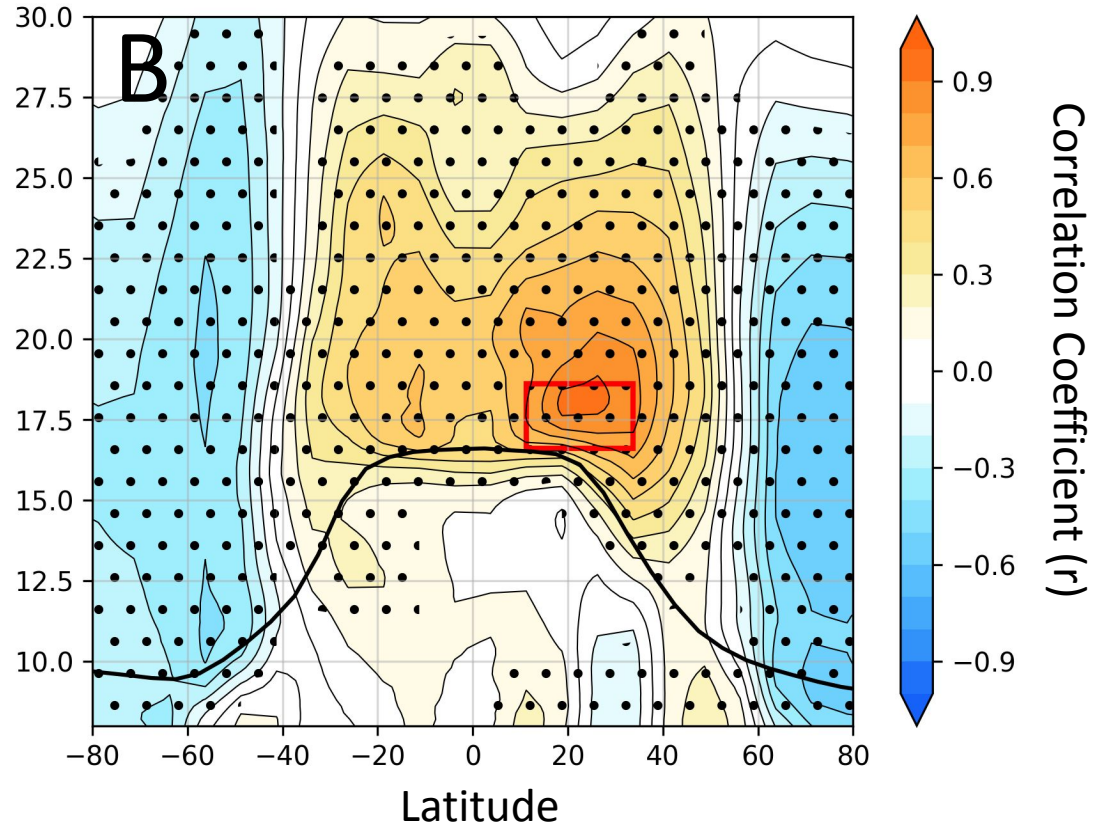
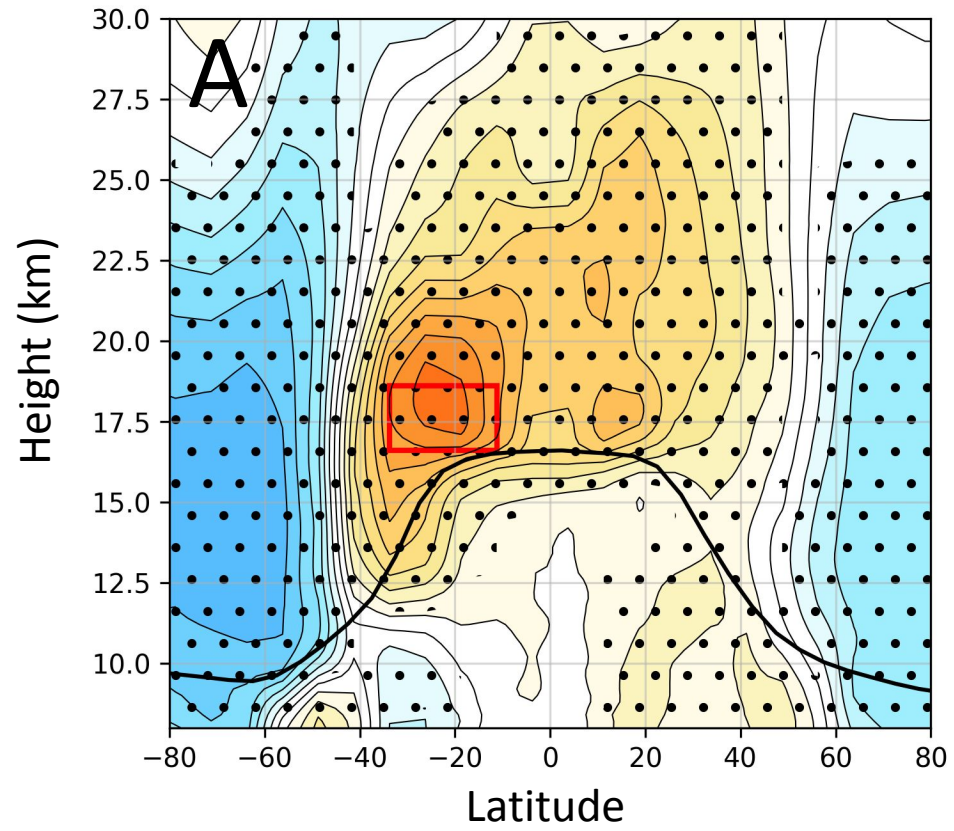


# The AWLS is dynamically induced

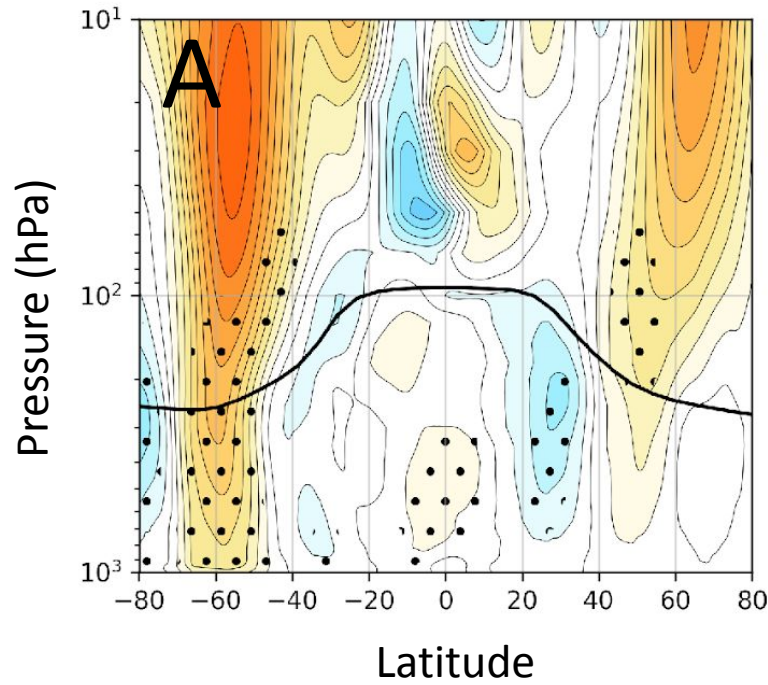
Regression Coefficients of AWLS and Temperature (detrended)



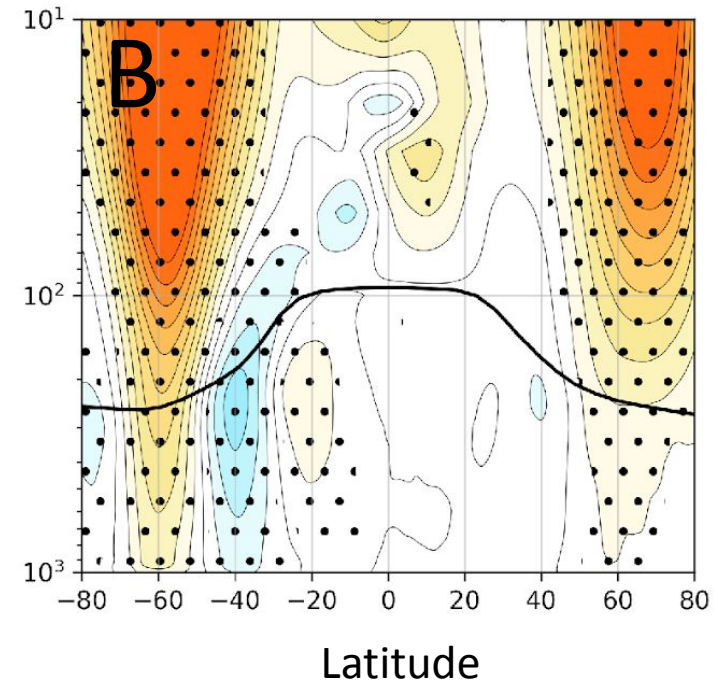




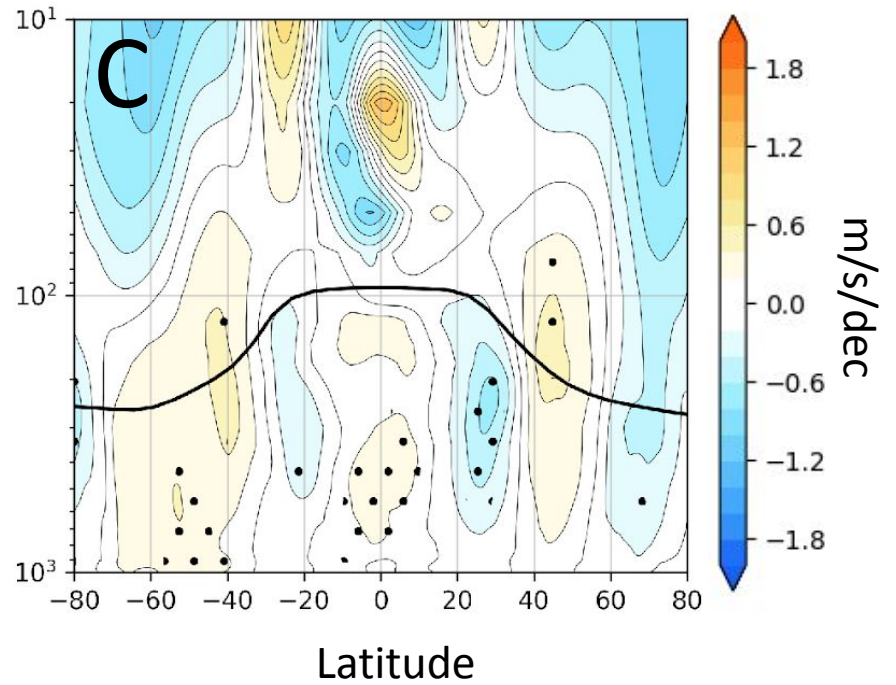
### Zonal Wind Trends (2002-2022)



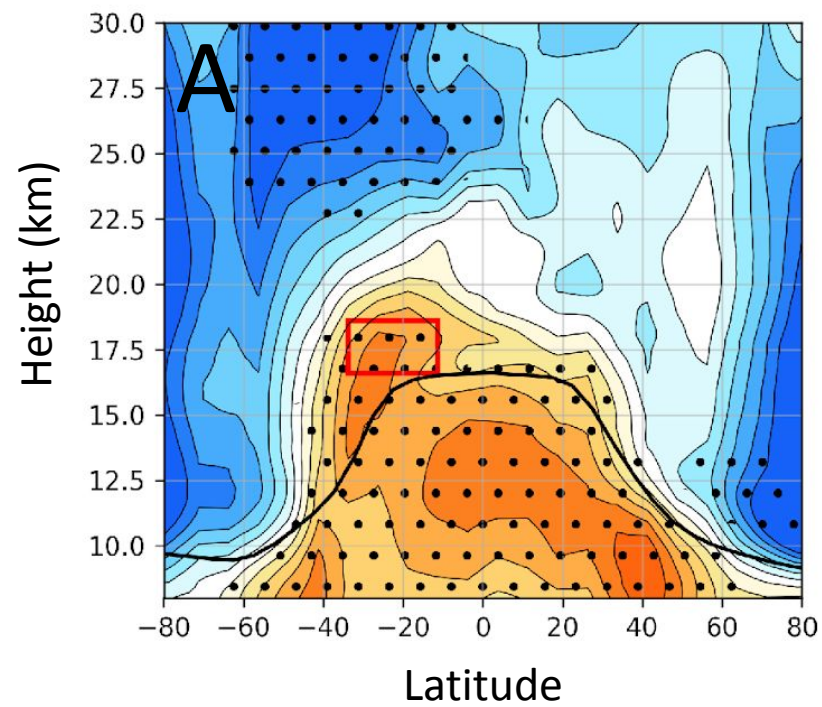
### Trends from Circulation Regression



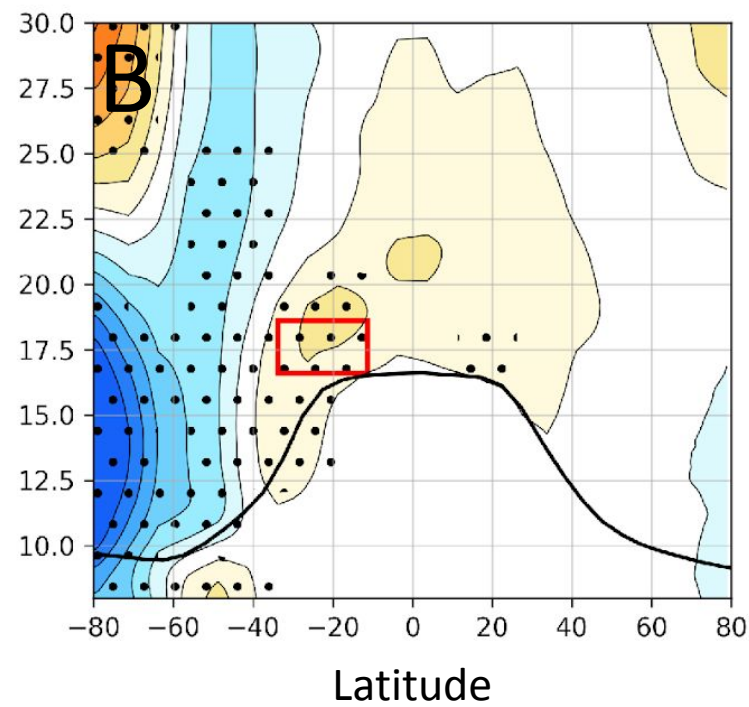
### Difference



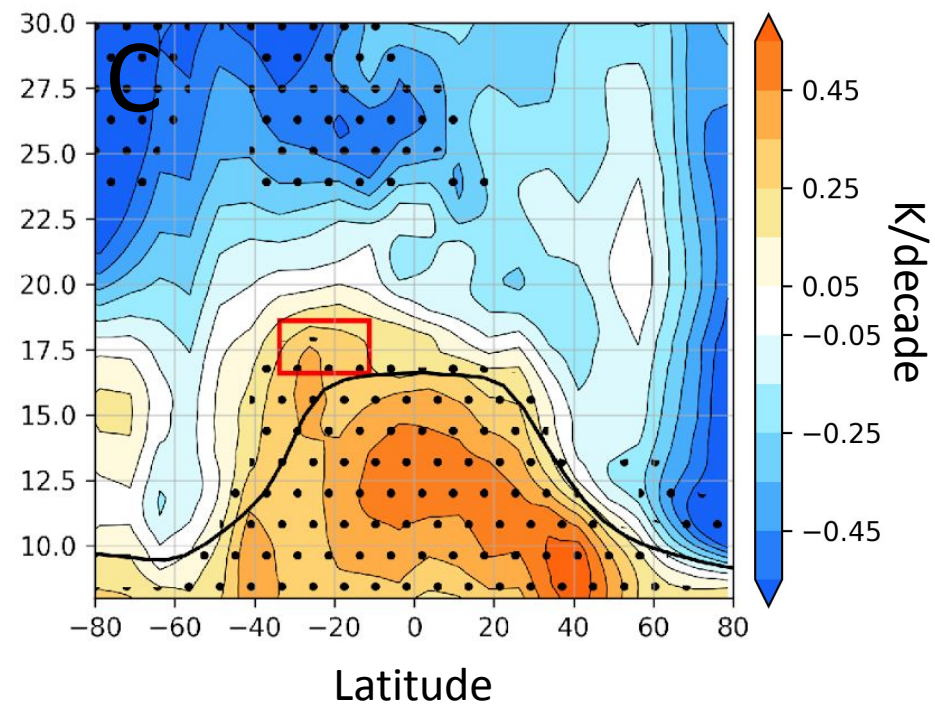
### Temperature Trends (2002-2022)



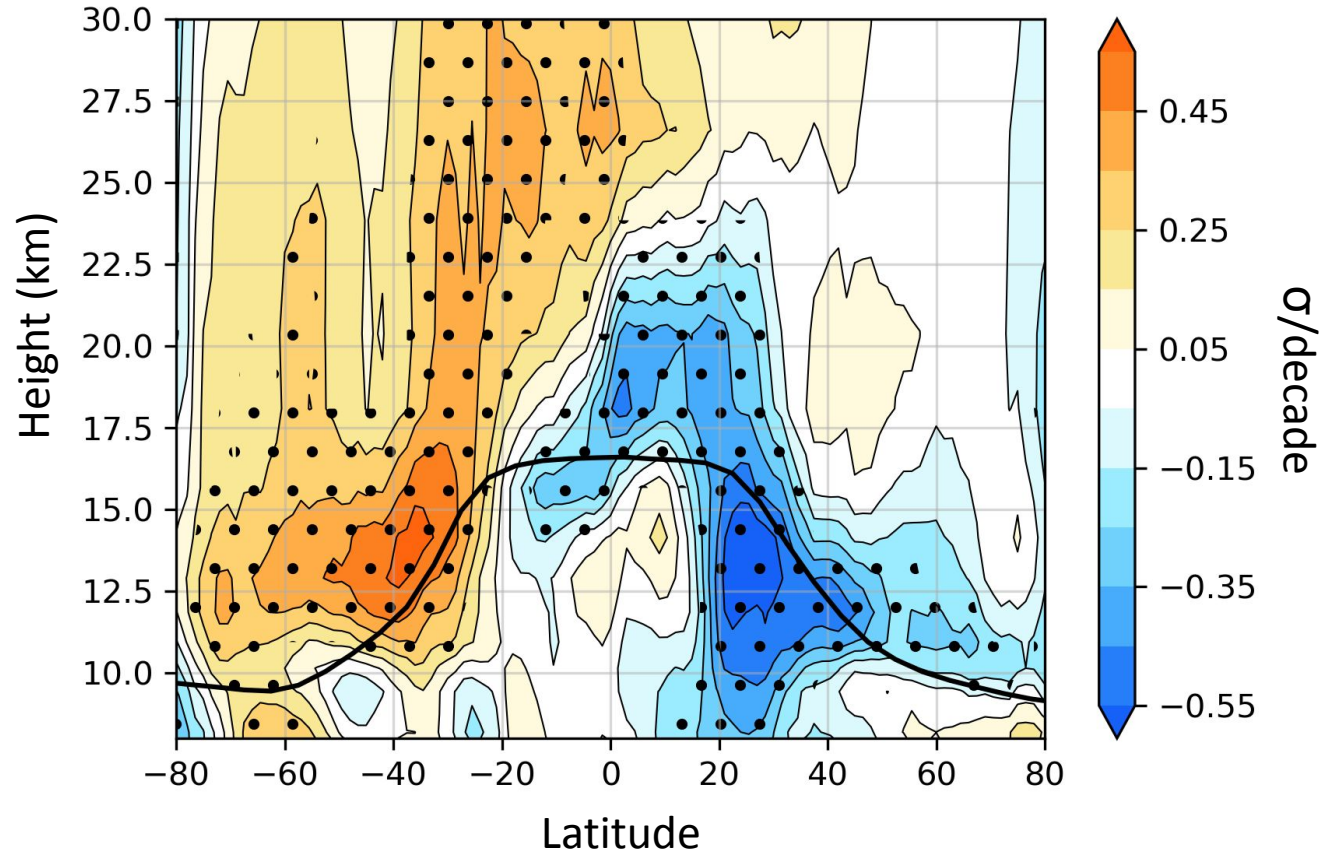
### Trends from SAM Regression

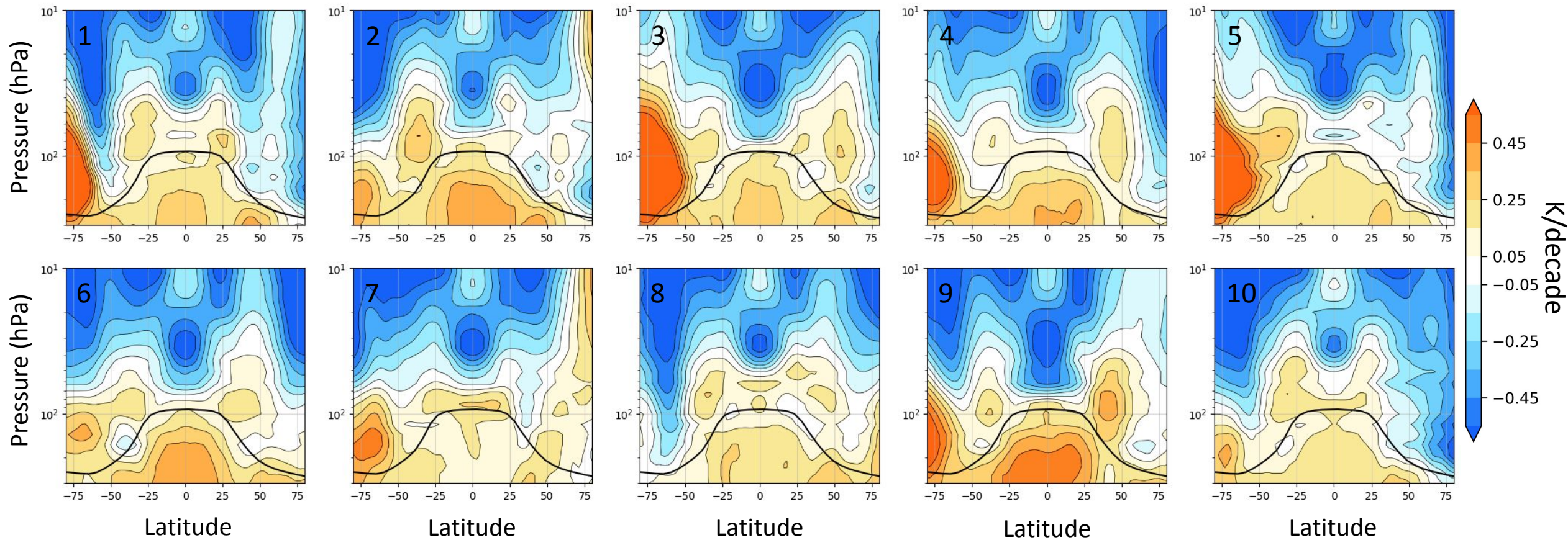


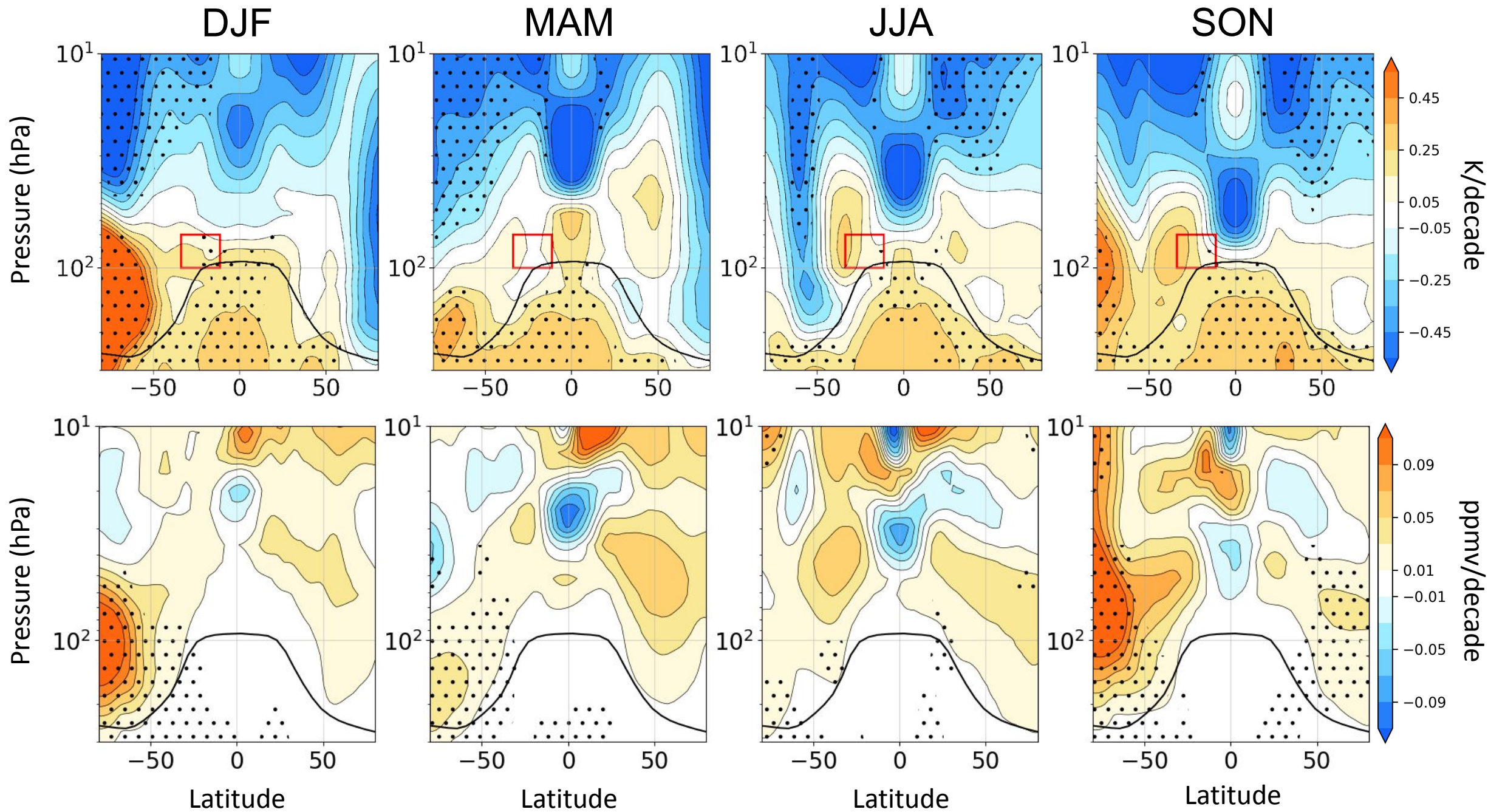
### Difference



# Residual Stream Function ( $\Psi^*$ ) Trends 2002-2022







Ozone Trends

Trends from circulation Regression

Difference

