Modeling Energetic Particle Precipitation and Transport with WACCM

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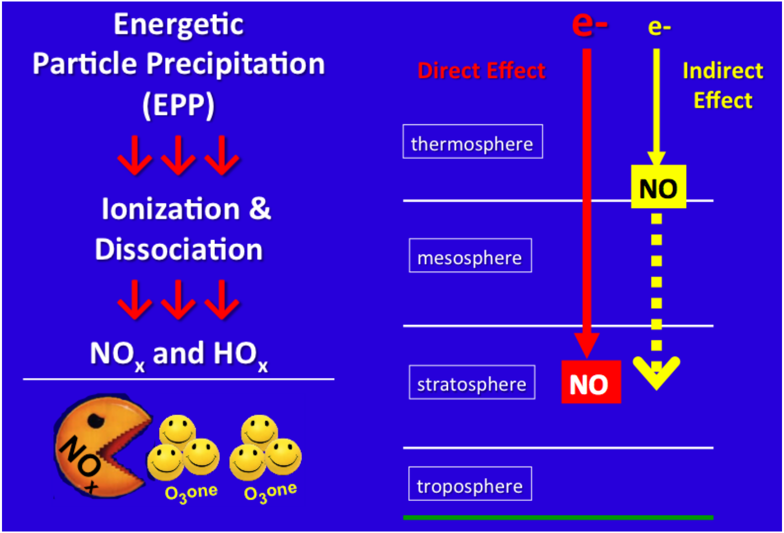
Energetic
Particle Precipitation
(EPP)
Ionization &
Dissociation
NOx and HOx
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O3one
O3one
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e-
Direct Effect
Indirect
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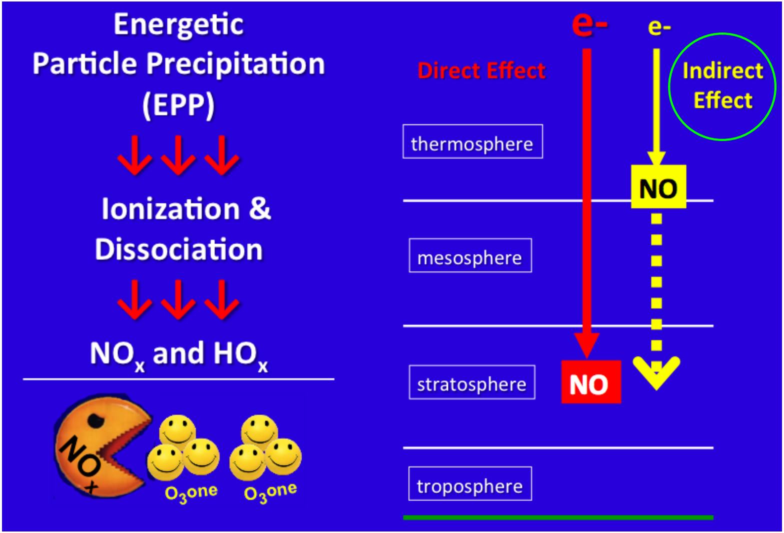
thermosphere
NO
mesosphere
stratosphere
NO
troposphere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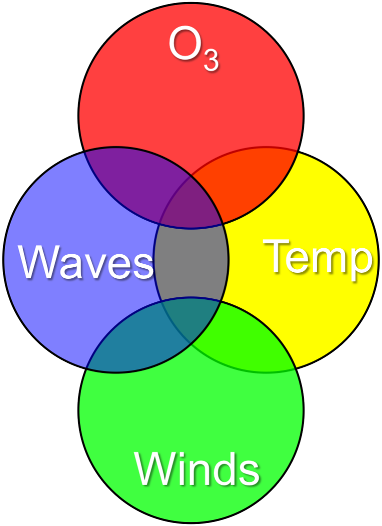

Changes in polar ozone trigger a redistribution of solar and magnetospheric energy at Earth

Research Goal

Determine the coupling mechanisms that redistribute solar and magnetospheric energy in the atmosphere.

Science Questions

- How does transport affect the distribution of NO_x created by EPP?
- How are the different regions of the atmosphere coupled through EPP?

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Need to use a model $\longrightarrow$ WACCM

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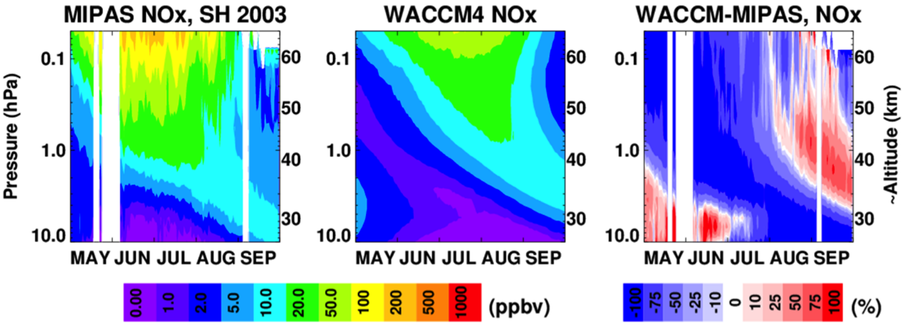
How does WACCM compare to observations?



Too low at beginning of season and lasts too long $\longrightarrow$
(1) residual circulation may be too low in WACCM
(2) WACCM only has auroral and SPEs

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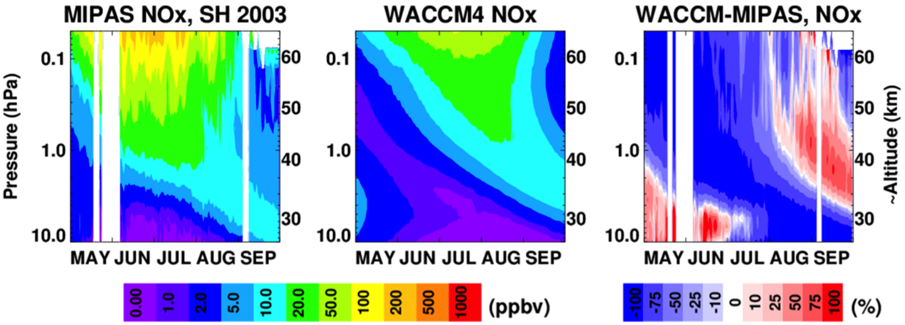

Too low at beginning of season and lasts too long ⟶
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Can we move the residual circulation up in WACCM by tuning taubgnd?

- Taubgnd controls amplitude of the GW source spectrum
- The amplitude of GWs determines where they break (lower amplitude=higher breaking)
- The GW forcing influences the residual circulation

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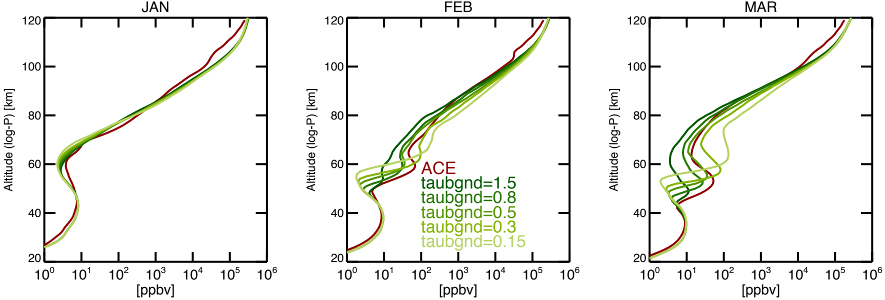
WACCM NO_x sampled at ACE locations for the NH 2006 compared to ACE



Decreasing taubgnd increases altitude of peak NO_x enhancement, but moves peak too high compared to ACE

Summary

- WACCM underestimates NO_x compared to observations
- Moving the residual circulation by tuning taubgnd doesn't appear to be enough to solve this problem
- A combination of tuning taubgnd and source strength will most likely produce better agreement between WACCM and observations

Other Results (Not Shown Here)

- However, WACCM shows evidence for coupling due to EPP even though the EPP Indirect Effect is underestimated in WACCM

What do we need?

Measurements

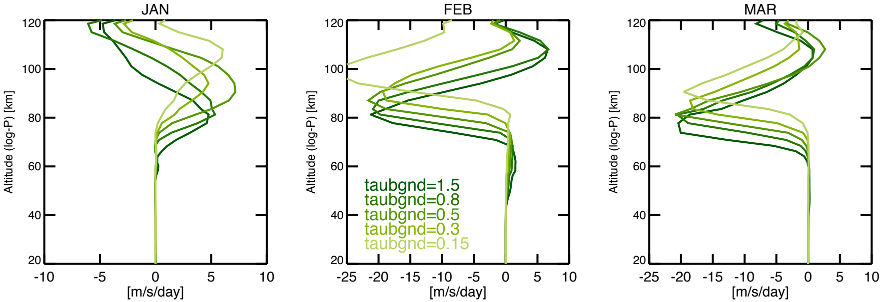
- NO_x throughout the polar winter, stratosphere to thermosphere
- NO_y and Cl_y
- Polar Mesospheric Clouds
- Winds in MLT
- Global ozone and temperature profiles
- Precipitating particles: energy spectrum and spatial distribution

Models

- Improved treatment of gravity waves in CCMs
- Incorporation of higher energy electrons in CCMs

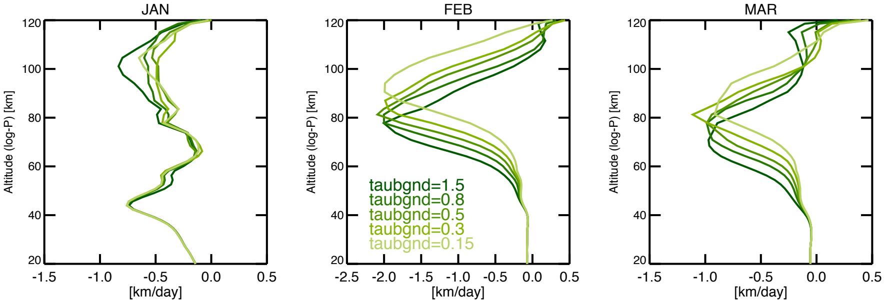
Thank You

WACCM gravity wave drag poleward of 70 N



Decreasing taubgnd moves GW momentum spectrum up

WACCM vertical residual circulation poleward of 70 N



Decreasing taubgnd moves peak descent up

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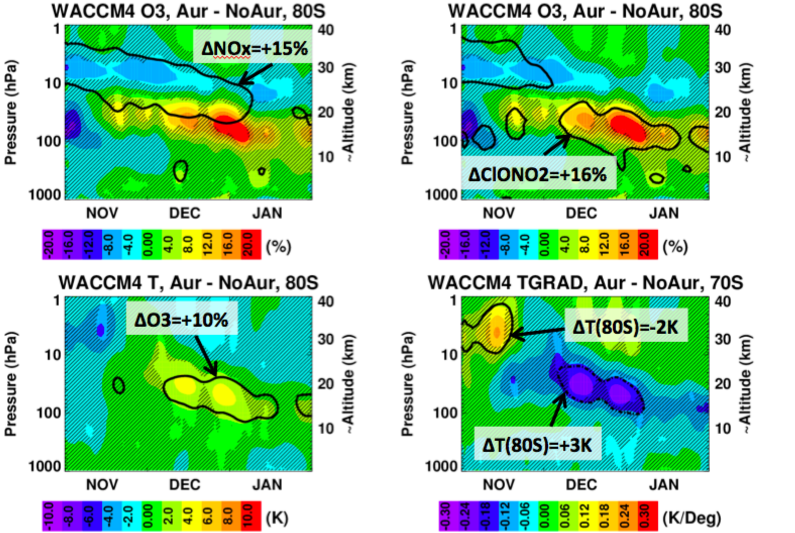
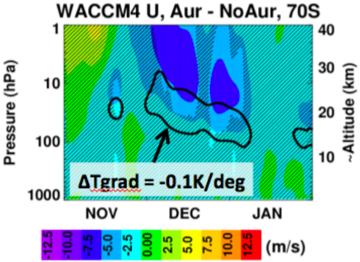
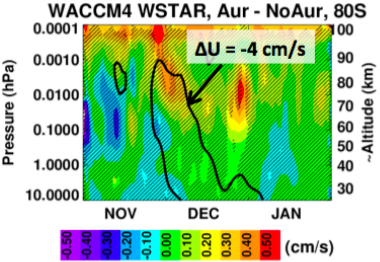
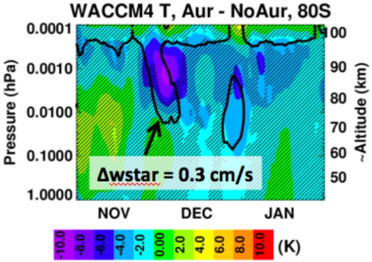


Upper left: Increased EPP-NOx causes O3 depletion and increased ClONO2. Upper right: Increased ClONO2 mitigates O3 loss. Lower left: Increased O3 causes temperature to increase. Lower right: Change in polar T leads to change in latitudinal T gradient at 70S.







Upper left: Changing latitudinal gradient in T causes U at 70S above to become more negative (easterly/summer) .

Upper right: Changing U at 70S affects GW filtering so that wbar* above, at 80S, is increased (i.e., stratospheric zonal wind more summer-like, leading to more ascent in the mesosphere) .

Lower left: Increase in wbar* leads to mesospheric cooling at 80S.