On the Role of Radiative Processes in Stratosphere-Troposphere Coupling

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BACKGROUND

Variability in the extratropical stratosphere is associated with circulation changes at both stratospheric and tropospheric levels. Such stratosphere-troposphere coupling has been documented in the cases of 1) recent Southern Hemisphere (SH) climate trends (e.g., Thompson and Solomon 2002) and 2) intraseasonal dynamic variability in the Northern Hemisphere (NH) stratospheric polar vortex (e.g., Baldwin and Dunkerton 2001). Most mechanisms hypothesized to explain stratosphere-troposphere coupling focus solely on atmospheric dynamics, and little consensus has been reached from these studies.

GOAL

To quantify the importance of radiative processes in driving the polar tropospheric temperature anomalies observed in association with stratosphere-troposphere coupling.

DATA

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Ozone</th>
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<tbody>
<tr>
<td>NH Dynamic Variability (60°N - 90°N) 1979-2003 NCEP-NCAR Reanalysis</td>
<td>November-April Resolute Ozonesonde</td>
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RESULTS


The differences between the observed and radiative responses reflect those processes explicitly neglected by the radiative calculations:
- Tropospheric dynamics (e.g., heat transport by baroclinic eddies)
- Radiative absorption at the surface
- Convective adjustment

NH Dynamic Variability Regressions upon inverted 10 hPa NAM Index

CONCLUSIONS

- Radiative processes clearly play a role in stratosphere-troposphere coupling, particularly in the SH trends case.
- The bulk of the net radiative response is attributable to the anomalous longwave radiation associated with stratospheric temperature changes. The "emissivity/transmissivity effect" of stratospheric ozone changes is negligible.
- For the SH trends case, both the amplitude and seasonality of the middle and upper tropospheric radiative response compare well with the observations.
- For the NH dynamic variability case, the radiative response extends deeper into the troposphere and persists longer than in the observations.
- Differences between the observed and radiative responses can likely be explained by tropospheric dynamics and surface radiative absorption.
- Radiatively induced temperature anomalies alter the meridional temperature gradient in the upper troposphere and could therefore trigger the changes in tropospheric dynamics observed in association with stratosphere-troposphere coupling.

REFERENCES


 observed near-surface cooling during December and January is likely attributable to changes in surface radiative absorption and tropospheric dynamics.

 observed surface cooling over high-latitude continents at large positive lags results from reduced zonal flow and temperature advection (e.g., Thompson et al. 2002).

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