Sensitivity of the Stratospheric Circulation to the Latitude of Thermal Surface Forcing

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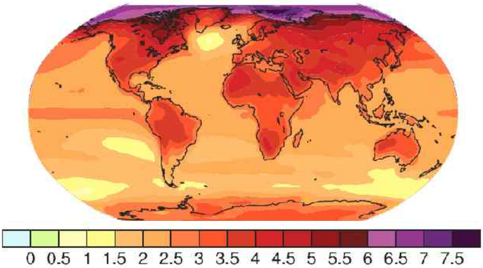
Outline:

1. Motivation and experiments
2. Thermal Surface Forcing in Latitudinal Bands
3. Thermal Surface Forcing in Combinations of Bands
4. Conclusions

Motivation:

- The surface temperature response to greenhouse gas forcing resembles horizontal bands of warm anomalies.

multi-model mean
ST anomaly (°C)
(annual)



IPCC AR4, A1B
2090-2099
(wrt 1980-1999)

- **How sensitive is the stratospheric circulation to the latitude of the surface heat anomaly?**

Model Description: IGCM-FASTOC

IGCM: Intermediate General Circulation Model

- Hoskins and Simmons (1975) spectral dynamical core
- T31 horizontal resolution
- 26 vertical layers (13 in stratosphere); resolution 2 km in the lower stratosphere, 4 km in the upper stratosphere; lid at 0.1 hPa.
- Betts-Miller moist/dry convection; Morcrette radiation; soil scheme; topography.

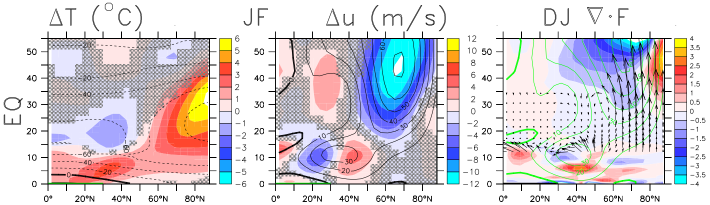
FASTOC: FAst STratospheric Ozone Chemistry

- Introduced in Bourqui et al. (2005) and Taylor and Bourqui (2005), FASTOC operates between the tropopause and the 4 hPa level.
- Chemically active species are O_x, NO_x, HO_x.
- No ozone hole; 1979 climatologies.

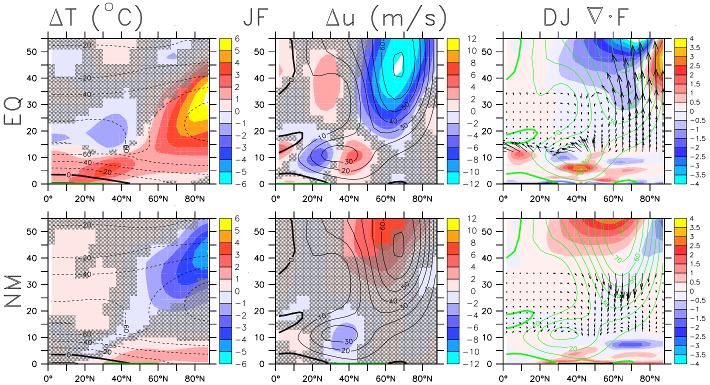
Thermal surface forcing in latitude bands:

Experiment		Extent of 2K forcing
wide bands	EQ	equator – 30°N
	NM	30°N – 60°N
	NP	60°N – 90°N
narrow bands	N1	equator – 10°N
	N2	10°N – 20°N
	N3	20°N – 30°N
	N4	30°N – 40°N
	N5	40°N – 50°N
	N6	50°N – 60°N
	N7	60°N – 70°N
	N8	70°N – 80°N
	N9	80°N – 90°N
combination bands	N1N4	eq. – 10°N, 30°N – 40°N
	EQNM	equator – 60°N
	EQNMP	equator – 90°N

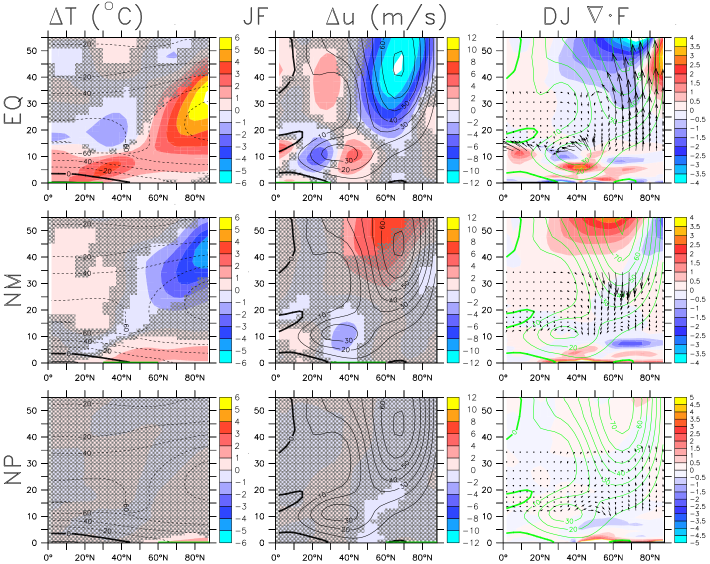
Winter response to surface forcing (EQ, NM, NP):



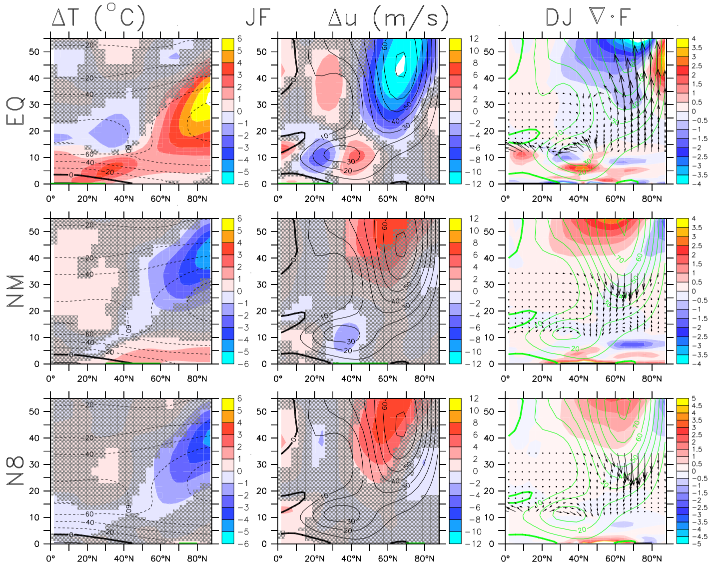
Winter response to surface forcing (EQ, NM, NP):



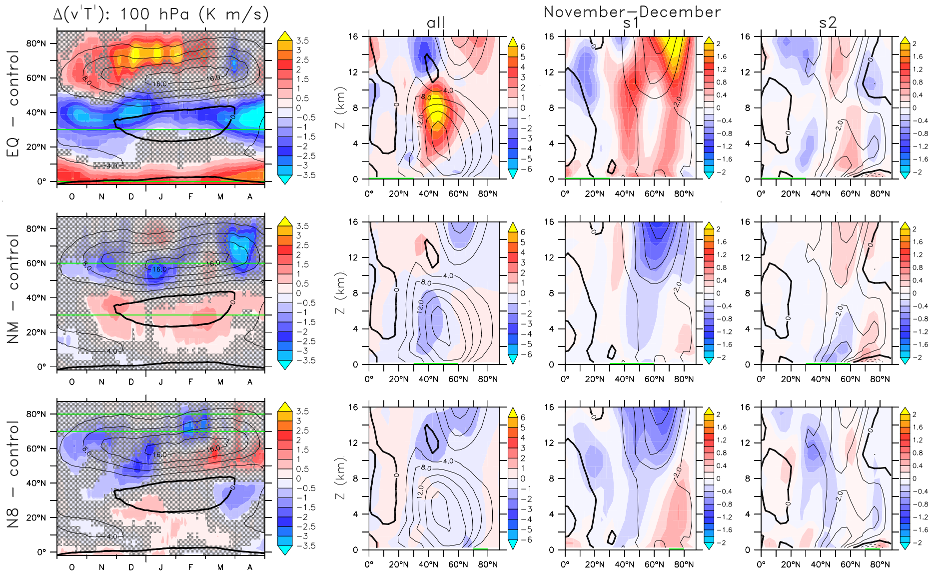
Winter response to surface forcing (EQ, NM, NP):



Winter response to surface forcing (EQ, NM, N8):



Response in $\overline{v'T'}$ (K m/s):



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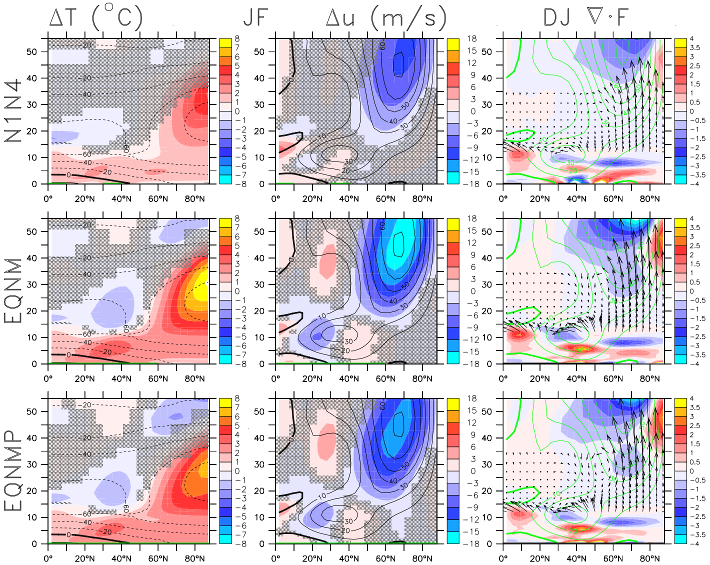
Surface forcing in combined bands (N1N4, EQNM, EQNMP):



Conclusions:

Surface forcing within the tropics:

- Stratosphere: high-latitude warm anomaly, reduction in vortex strength in mid-winter; stronger vertical EP flux in the early winter.
- Troposphere: warmer tropics and extratropics, higher tropical tropopause, poleward shift of the jet.

Surface forcing between 30°N and 60°N:

- Stratosphere: high-latitude cold anomaly and stronger vortex in mid-winter; decrease in early winter vertical EP flux.
- Troposphere: warmer in mid- to high latitudes, weaker jet.

Surface forcing poleward of 60°N:

- Stratosphere: qualitatively the same as for mid-latitude forcing.
- Troposphere: cooling of tropical mid-troposphere, no change in jet.

Tropical forcing dominates the response when bands are combined.