Spatial structure of the quasi-biennial oscillation in zonal wind and ozone simulated with the MRI-CCM

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**MRI-CCM (Shibata et al., 2005)**

- Chemistry: full chemistry and transport processes
- dynamics: full dynamics and transport processes
- 74 long-lived species including 7 halogen
- 15 short-lived species which are diagnosed
- 7 photodissociation and 90 gas phase reactions
- 9 heterogeneous reactions on PSCs and sulfate aerosols
- 35 photodissociation and 80 gas phase reactions
- 36 long-lived species including 7 families
- 15 short-lived species (which are diagnosed)
- Hybrid semi-Lagrangian scheme
- Vertically, flux-form semi-Lagrangian scheme (piecewise rational method)
- Horizontally, box-form semi-Lagrangian scheme (pseudo-relaxation method)
- Gravity Wave Drag
- Hines (1997) parameterization with enhanced source in the tropics

**Summary**

- Ensemble (five members) simulation of the middle atmosphere over the past 25 years (from 1980 to 2004) was performed with the MRI-CCM by imposing observed natural and anthropogenic forcings of SST, sea ice, greenhouse gases, halogens, the 11-year solar cycle, and volcanic aerosols.
- The seasonality of the mid-latitude total ozone QBO, which extends poleward with opposite sign to the equatorial total ozone QBO in the winter hemisphere, is also quantitatively reproduced in the QBO20 signal, although there is no extension to high latitudes in the spring time.