Evaluation of the Whole Atmosphere Community Climate Model Distributions of Chemical Constituent in the Extratropical Stratosphere

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Motivation:
To understand the impact of including (or not) a QBO forcing into the WACCM model - specifically in regards to the impact that this forcing has on extra tropical constituent distributions. Ozone comparisons are made with the NASA Aura HIRDLS instrument (version 4.0).

Conclusion:
- Tropical ozone is modulated significantly when a QBO forcing is included. Here ozone is controlled by QBO induced transport of NOY (i.e., NOx odd-ox loss cycles).
- The mean circulation is also modified, warming the cold point (not shown) and increasing strat. H_2O abundance.
- Including a QBO forcing in a CCM increases O_3 in the extra tropical stratosphere for any given year, however, there is little difference in long term climatologies (Figures 3-4).
- Comparisons of O_3 from HIRDLS and WACCM3 driven with GMAO GEOS5.1 meteorological fields are in good agreement for years 2006 and 2007 (Figure 2). This comparisons validates the accuracy of the transport and chemical schemes employed in WACCM3.

Model Description: Garcia *et al.*, JGR, 2007.
Resolution: 4°x5° and 66 L (surface – 150 km)
Chemistry: 57 species that represents the middle atmosphere (JPL06).
Dynamics: Fully interactive or driven with GEOS5.1 Met. Fields.
Simulations, Table 1:

Sim	Trace Gas	Solar Variability	Sulfate SAD	Obs SSTs	Obs QBO	Dynamics	Period
1	Yes	Yes	Yes	Yes	NO	Coupled	1990-2008
2	Yes	Yes	Yes	Yes	Yes	Coupled	1990-2008
3	Yes	Yes	Yes	Yes	NA	GEOS 5.1	2004-2008

The above forcings are all time varying. WACCM3 Version 3.5.48

HIRDLS Instrument overview: Gille *et al.*, JGR, 2008.
Aura Satellite: Sun-synchronous near-polar orbit.
HIRDLS data: Jan 2005 – Mar 2008: 64°S-80°N; ~5500 profiles day^{-1}
Vertical Res: Typically 1-2 km.
L3 product: Data binned on to 5°x20° lat x lon (daily).
O_3 Validation: Nardi *et al.*, JGR, 2008.

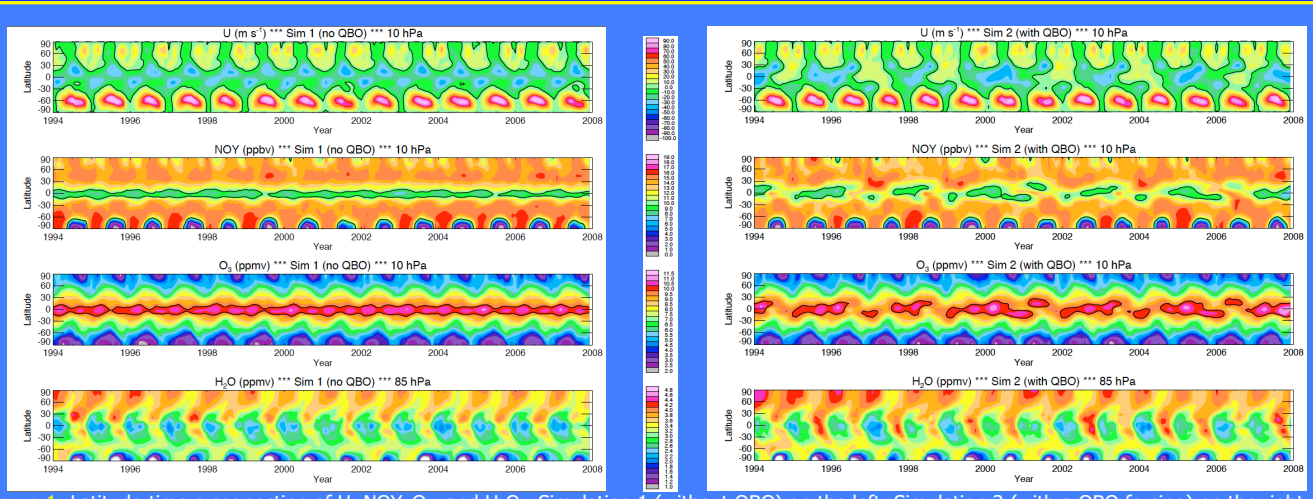

Figure 1: Latitude-time cross section of U, NOY, O_3, and H_2O. Simulation 1 (without QBO) on the left; Simulation 2 (with a QBO forcing) on the right.

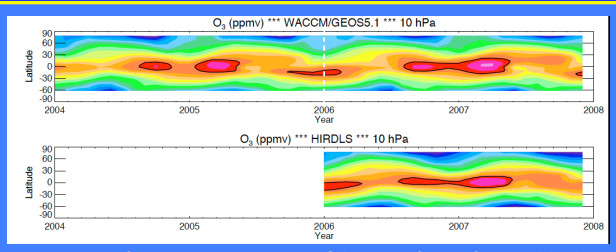

Figure 2: Latitude-time cross section of O_3 at 10 hPa. The WACCM3 results are from Simulation 3, i.e., driven with GEOS5.1 met. fields.

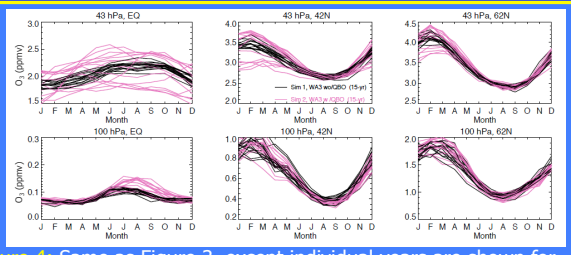

Figure 4: Same as Figure 3, except individual years are shown for simulation 1 (wo/QBO; black) and 2 (w/QBO; red).

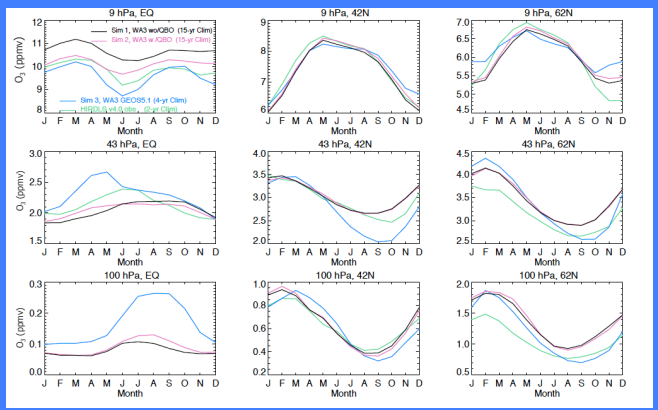

Figure 3: Comparisons of O_3 (ppmv) at the Equator, 42°N, and 62°N at three pressure levels (9 hPa, 43 hPa, and 100 hPa). Two 15-year climatologies (1993-2007) were created for simulation 1 and 2 (black and solid red lines respectably). A 4-year climatology was created for Simulation 3 (blue line). A two year climatology was created using the HIRDLS data for years 2006 and 2007 (green line).