The QBO in Model-Simulated and Observed Equatorial Temperature of the Lower Stratosphere

Curt Covey and Stephen Po-Chedley, PCMDI / Lawrence Livermore National Lab*

... with thanks for advice and data from:
- John Christy, NASA / University of Alabama at Huntsville
- Rolando Garcia and Jaga Richter, NCAR
- Jeff Painter and Ben Santer, PCMDI / Lawrence Livermore National Lab

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WACCM Gets a QBO in Near-equatorial Winds . . . and Temperatures

Garcia and Richter (2019)

JOURNAL OF THE ATMOSPHERIC SCIENCES

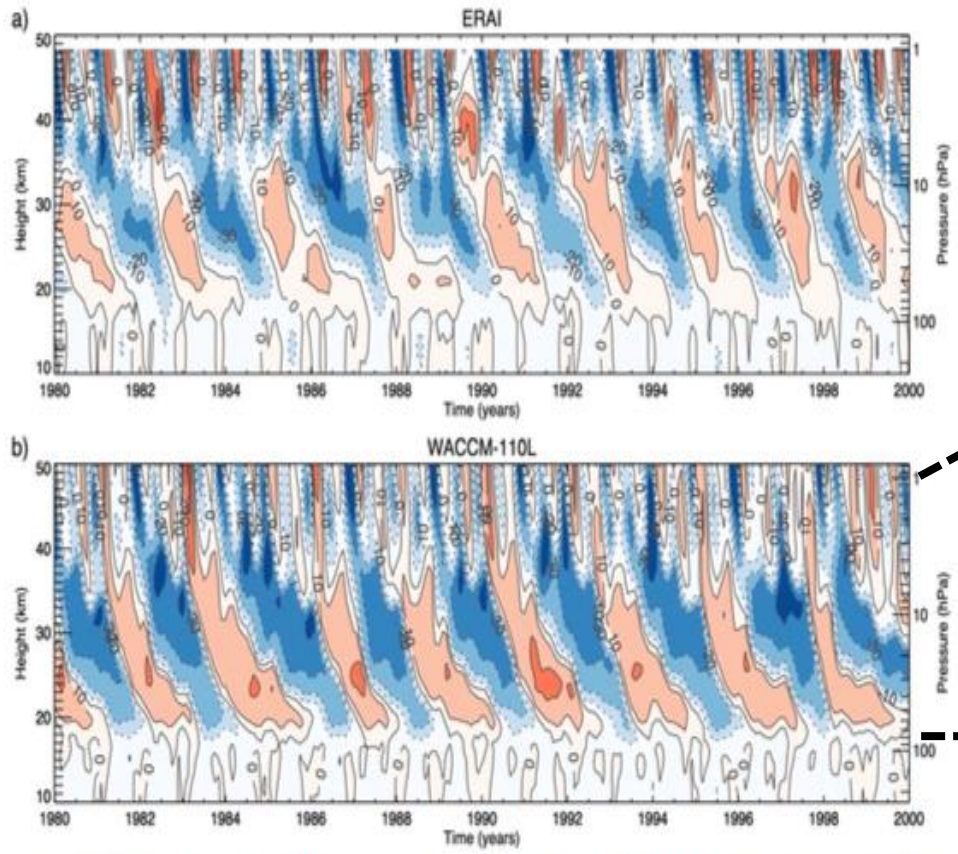
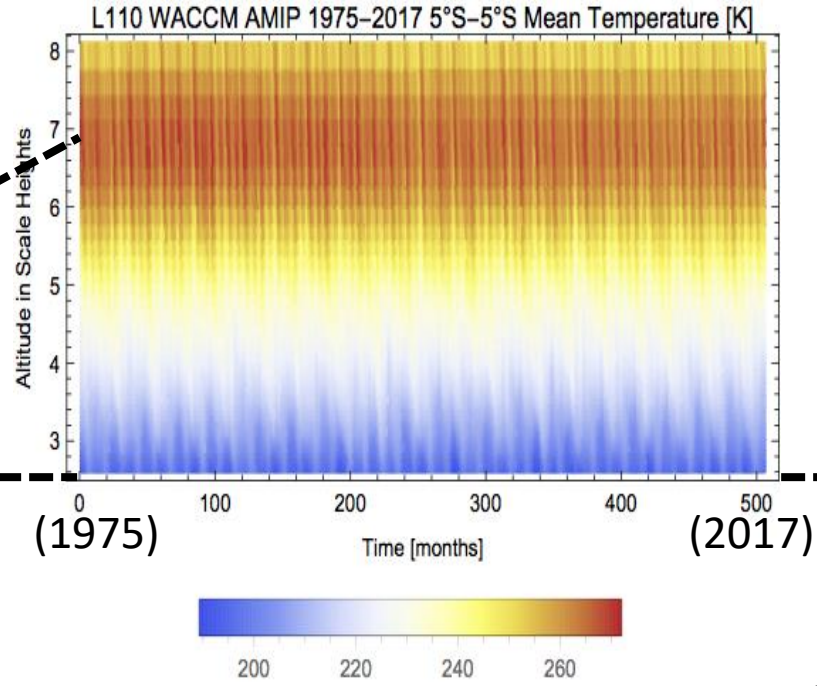
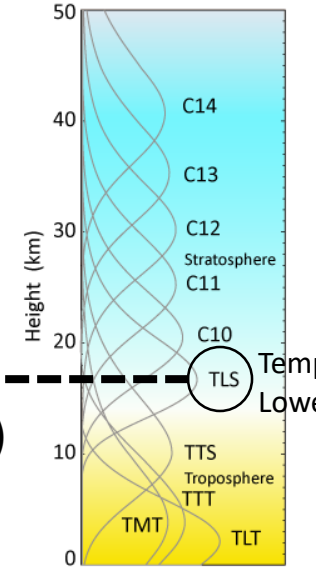


FIG. 4. (bottom) Zonal-mean zonal wind ($m\ s^{-1}$) averaged over ±2.36° in WACCM-110L, compared with (top) data from ERAI averaged over ±2.45° for the period 1980–2000.

Model-simulated temperatures can be compared with satellite observations of microwave brightness temperatures . . . if convolved with the appropriate weighting function





Temperature of Lower Stratosphere

Weighting functions from Remote Sensing Systems (www.remss.com/measurements/upper-air-temperature)

JOURNAL OF CLIMATE VOLUME 7

(1994)

Variability in Daily, Zonal Mean Lower-Stratospheric Temperatures

JOHN R. CHRISTY

Atmospheric Science Program, University of Alabama in Huntsville, Huntsville, Alabama

S. JAMES DROUILHET, JR.

Department of Mathematical Sciences, Moorhead State University, Moorhead, Minnesota

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ABSTRACT

Satellite data from the microwave sounding unit (MSU) channel 4, when carefully merged, provide daily zonal anomalies of lower-stratosphere temperature with a level of precision between 0.01° and 0.08°C per 2.5° latitude band. Global averages of these daily zonal anomalies reveal the prominent warming events due to volcanic aerosol in 1982 (El Chichón) and 1991 (Mt. Pinatubo), which are on the order of 1°C.

The quasibiennial oscillation (QBO) may be extracted from these zonal data by applying a spatial filter between 15°N and 15°S latitude, which resembles the meridional curvature. Previously published relationships between the QBO and the north polar stratospheric temperatures during northern winter are examined but were not found to be reproduced in the MSU4 data.

Sudden stratospheric warmings in the north polar region are represented in the MSU4 data for latitudes poleward of 70°N. In the Southern Hemisphere, there appears to be a moderate relationship between total ozone concentration and MSU4 temperatures, though it has been less apparent in 1991 and 1992.

In terms of empirical modes of variability, the authors find a strong tendency in EOF 1 (39.2% of the variance) for anomalies in the Northern Hemisphere polar regions to be counterbalanced by anomalies equatorward of 40°N and 40°S latitudes. In addition, most of the modes revealed significant power in the 15–20 day period band.

Bottom line of this talk:

It's no longer necessary to invoke latitude correlations in order to extract the QBO from satellite-observed LST . . . but it helps with WACCM output.

The Simplest Possible Fourier Analysis

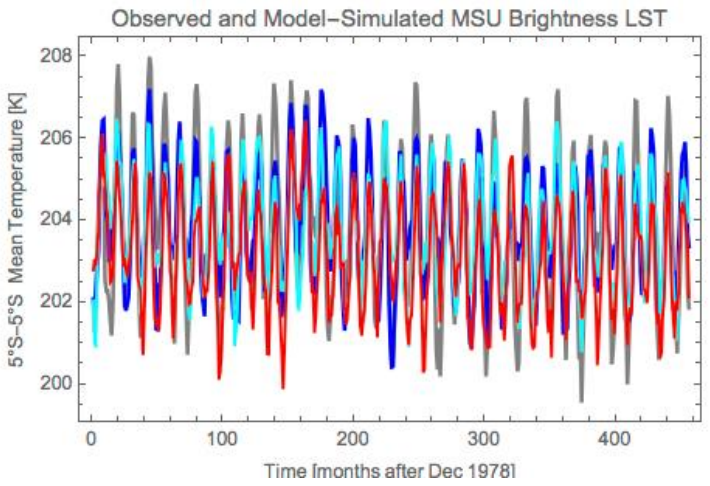
WACCM output from ...
- 110-level AMIP run, including volcanos
- 110-level coupled atmosphere-ocean-seaice run, **not** including volcanos
- 70-level coupled run, including volcanos

MSU/RSS Satellite Observations
L110 AMIP WACCM withVolc
L110 coupled WACCM noVolc
L70 coupled WACCM withVolc

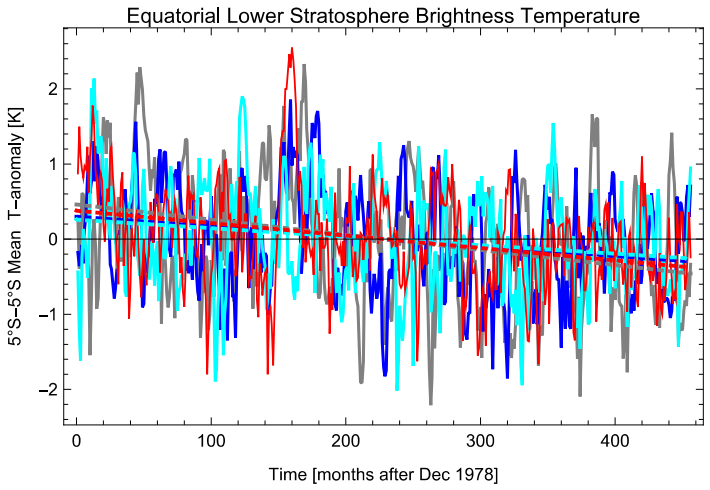
1. Apply microwave LST simulator algorithm (Santer et al 2013).

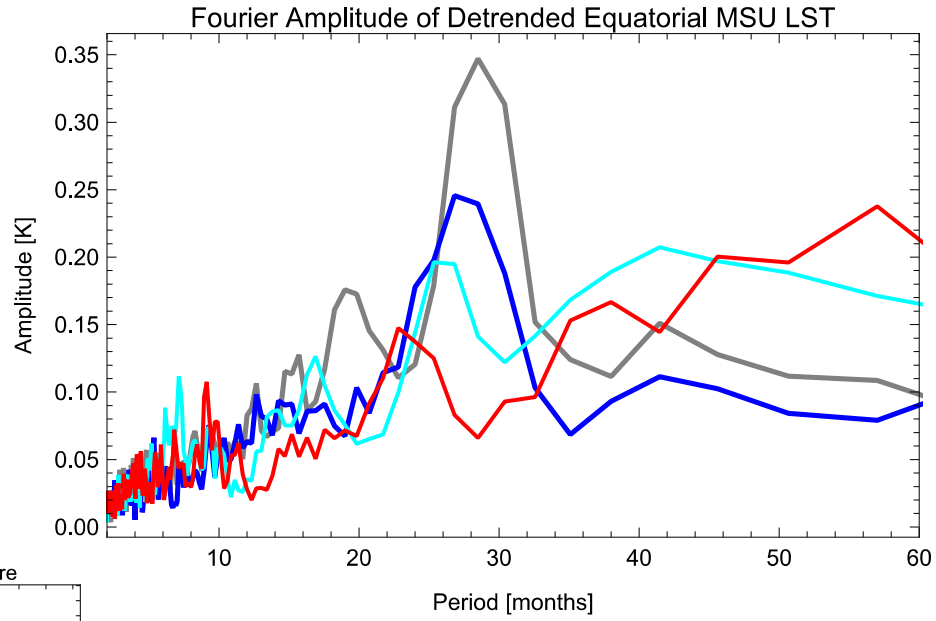
Satellite microwave obs (processed by RSS)

2. Area-average near Equator (latitudes 5S – 5N).



3. Remove seasonal cycle.





4. Remove linear trend.
5. Solve N equations in N unknowns:

$$T_n = \sum_{s=0}^{N-1} f_s \, e^{-2\pi i n s/N} \qquad n = 0, 1, 2, \ldots, N-1$$

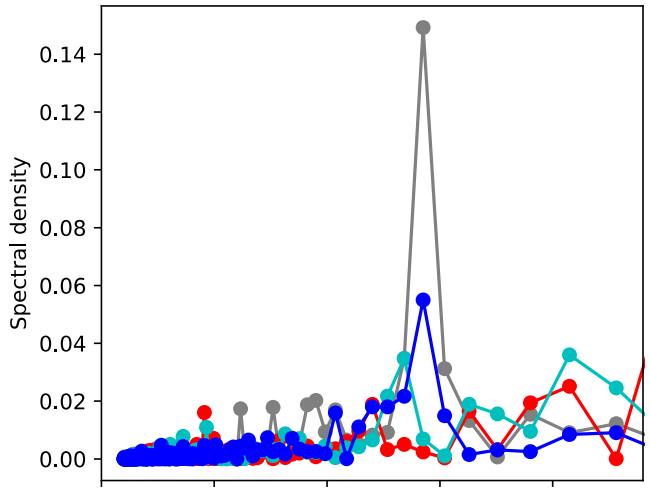
$$\updownarrow$$

$$f_s = \sum_{s=0}^{N-1} T_n \, e^{+2\pi i n s/N} \qquad s = 0, 1, 2, \ldots, N-1$$

6. Apply 3-point running mean.

More Sophisticated Fourier Analysis

Windowing in place of explicit smoothing →



MSU/RSS Satellite Observations
L110 AMIP WACCM withVolc
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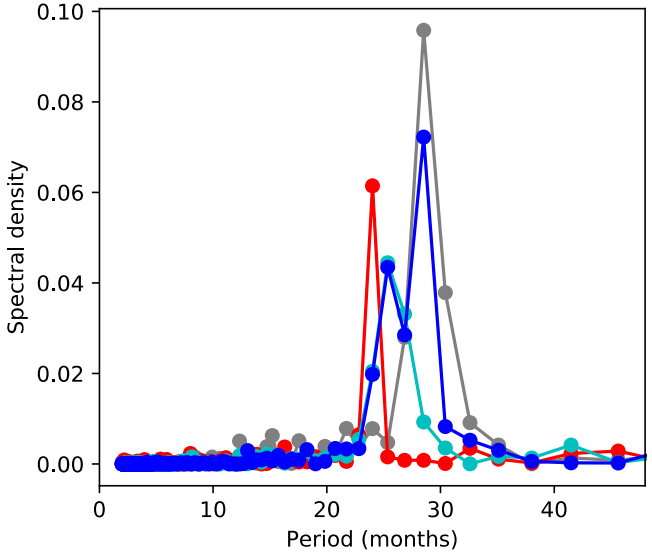
Christy / Drouilhet latitude “filter” in place of near-equatorial averaging →



Statistical confidence limits:

1. Chi-square test with *n* degrees of freedom?
2. Bootstrapping??