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Reconstructing the Quasi-Biennial Oscillation back to 1900

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The Quasi-Biennial Oscillation (QBO) is an essential component for understanding the chemical and dynamical variability of the global stratosphere. Currently, the available upper level wind data in the equatorial stratosphere extend back to 1953. Here we present historical reconstructions of the QBO (the equatorial zonal wind at different pressure levels from 3 to 90 hPa) extending back to 1900. The aim is to obtain model boundary data for "nudged QBO" climate simulations of the 20th century. For this application, it is crucial that the reconstructed QBO is physically plausible, exhibits realistic amounts of variability, and is in phase with the true QBO. Consequently, we started with a perpetually repeating, representative QBO cycle (for this purpose we chose the period from 9/1995 to 11/1997 in ERA40 reanalysis wind data). This series was then phase shifted and locally stretched in time (using linear interpolation) to match the true QBO.

Information on the true QBO came from two sources, namely the solar semidiurnal tide detectable in hourly sea-level pressure data from Jakarta (this signal is related to ozone heating in the stratosphere, which in turn is modulated by the QBO) and from very sparse direct wind measurements from tropical pilot balloon observations. We extracted a QBO signal from the monthly amplitudes of the solar semidiurnal tide using a bandpass filter with half-power points at 24 and 32 months. The sequences of minima and maxima in the filtered series were then temporally mapped onto the minima and maxima (at 25 hPa) of the replicated QBO cycle. This first reconstruction was subsequently corrected by changing the interpolation between minima and maxima such as to best match the observed QBO phases (i.e., the sparse pilot balloon winds). Only slight stretching was necessary, except during the early 1940s where the agreement between observational QBO data and the semidiurnal tide QBO signal was bad. The final product is a physically plausible QBO that co-varies with most of the

sparse historical observations. Total ozone data from various stations extending in time back to 1924 were used to independently validate these reconstructions. The identical band-pass filter was applied to the ozone data. The series were then calibrated against the QBO during the satellite period (1979-2000) to reconstruct the QBO during the historical period. The agreement between these two reconstruction methodologies is very good. Nevertheless, an analysis of the data with respect to the Holton-Tan effect is inconclusive and suggests that there might still be large uncertainties.