

# **Short-Term Trends in Stratospheric Circulation Driven by Seasonal Timing of the Quasi-Biennial Oscillation**

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Cooling of the stratosphere associated with increasing concentrations of greenhouse gases is expected to lead to a strengthening of the stratospheric circulation. Global chemistry-climate models indicate that this strengthening is already occurring, but observation-based studies have led to mixed results. Here we use a model and satellite observations to show that changes in the lag between the Quasi-Biennial Oscillation (QBO) in tropical winds and the seasonal cycle in tropical upwelling can drive decadal-scale circulation trends that are likely to make detection of long-term changes challenging given the length of observational records. Using satellite records and a chemistry-climate model, we find that changes in the seasonal timing of the QBO have driven a series of 4 short-term circulation trends with alternating sign over the past two decades, with maximum changes in upwelling of ~30%. We further show that these decadal-scale trends in circulation explain many of the observed changes in trace gases over the same period and that these trends, while driven by the QBO, are not removed in typical analyses that account for the influence of the QBO on circulation and trace gas concentrations through multiple linear regression.

Key words: Stratospheric circulation, QBO