

Long-term trend in the stratospheric quasibiennial oscillation and tropical mean upwelling

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The zonal-mean zonal circulation in the tropical stratosphere is dominated by the quasibiennial oscillation (QBO) between prevailing easterlies and westerlies with periods of about 28 months. The vertical structure of the QBO in the lowermost stratosphere is linked to the mean upwelling there, which itself is a key factor in determining stratospheric composition. We report on an analysis of near-equatorial radiosonde observations for 1953-2012 and reveal a previously unknown long-term trend of weakening amplitude in the QBO of zonal flow in the tropical lower stratosphere. The trend is particularly notable at 70 hPa (~19 km), where amplitudes dropped by roughly 1/3 over the period. This trend is also apparent in the global warming simulations of the four models in the Coupled Model Intercomparison Project Phase 5 (CMIP5) that realistically simulate the QBO. This effect is most reasonably explained as resulting from a trend of increased mean tropical upwelling in the lower stratosphere. Almost all comprehensive climate models have projected an intensifying tropical upwelling in global warming scenarios, but attempts to estimate changes in the upwelling by using observational data have yielded ambiguous, inconclusive, and/or contradictory results. Discovery of a significant trend in the lower stratosphere QBO amplitude provides strong support for the existence of a long-term trend of enhanced upwelling near the tropical tropopause and this trend can be considered a subtle, but robust, indicator of the response of the climate system to anthropogenic forcing over recent decades.

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