

METEOROLOGY OF THE TROPICAL STRATOSPHERE

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Summary

The general circulation of the tropical stratosphere is reviewed. Observations of the winds and temperatures reveal characteristic long-period oscillations of the zonal-mean circulation in the tropical stratosphere, notably the very prominent quasi-biennial and semiannual oscillations. The characteristic observed features of the quasi-biennial and semiannual oscillations are described and the dynamical mechanisms thought to be responsible for driving these long-period oscillations are discussed. The role of the quasi-biennial oscillation in variations of stratospheric composition is considered. The possible effects of the stratospheric quasi-biennial oscillation on the tropospheric circulation are described and the implications for seasonal predictability of the atmosphere are considered.

1. Introduction

Near the equator the tropopause is normally observed at altitudes of about 17-18 km above sea level, corresponding to pressures near 100 hPa. Away from the equator the tropopause drops somewhat, but generally at tropical latitudes there is a well-defined tropopause at a height of at least 15 km. The stratopause near the equator is normally located near 50 km altitude, corresponding to pressures of about 1 hPa. The circulation in the layer between the tropopause and stratopause at tropical latitudes displays some remarkable and unique features. The most distinctive aspects of the circulation in the tropical middle atmosphere are the large-amplitude, quasi-regular, long-period oscillations seen in the zonally-averaged wind and temperature. The tropical circulation in the lower and middle stratosphere is dominated by the quasi-biennial oscillation, while the region from the near stratopause displays a prominent semiannual oscillation.

2. Quasi-biennial Oscillation

2.1. Discovery

The first knowledge of the winds in the tropical stratosphere was obtained from observations of the motion of the aerosol cloud produced by the eruption of Mt. Krakatau (in modern-day Indonesia) in August 1883. The optical phenomena caused by the aerosol were remarkable enough so that their first appearances were widely noted. From observations reported anecdotally from over 30 locations in the tropics, the motion of the edge of the dust cloud in the first few days after the eruption can be plotted (Figure 1). The regular westward motion is evident with a speed of about 30 m/s. Although the existence of the stratosphere was unknown at the time, the contemporary estimates of the height range of the dust cloud suggest that the dust penetrated well into the stratosphere. The reasonable interpretation is that the westward propagation of the dust cloud indicated the existence of strong easterly winds near the equator at some level in the stratosphere in August 1883.

Regular balloon observations of the winds above the tropopause (typically up to 50 hPa in early years and to 10 hPa more recently) began at a number of tropical stations in the early 1950s. By the end of the decade it was obvious that prevailing easterlies and westerlies alternated with a roughly biennial period. Initially it was thought that the period of the oscillation might be exactly two years, but as measurements accumulated it soon became clear that the period of oscillation was somewhat irregular and was longer, on average, than 2 years. By the mid-1960s the term “quasi-biennial oscillation” (QBO) had been coined to denote this aspect of the stratospheric circulation.

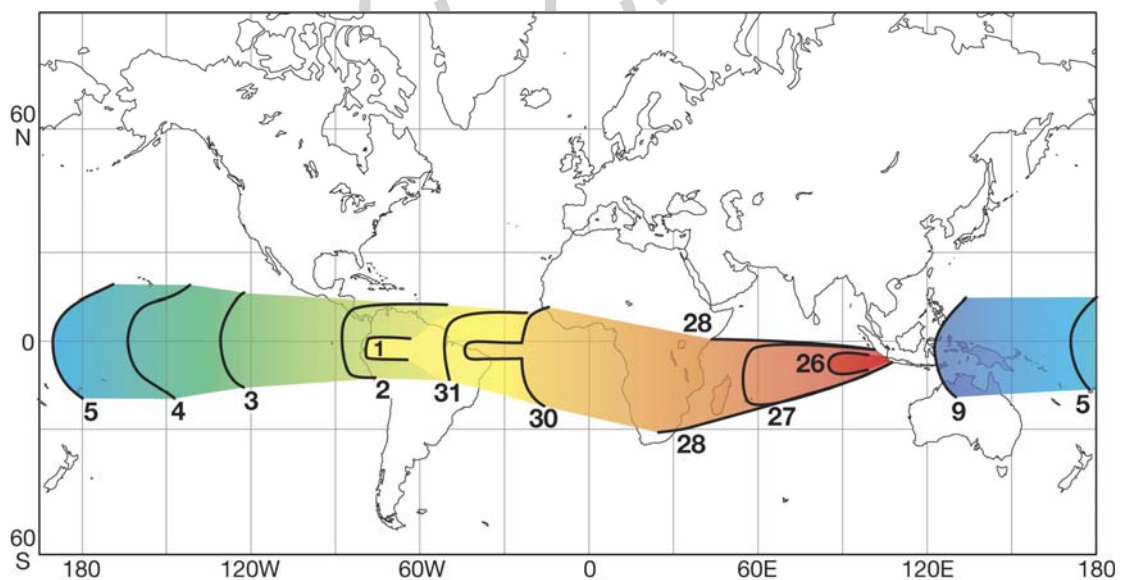


Figure 1. The black lines show the estimated western boundary of the aerosol cloud resulting from the 1883 eruption of Mt. Krakatau for August 26, 27, 28... September 9, based on reported sightings of unusual atmospheric optical phenomena. adapted from F.A.R. Russell, (1888) *The spread of the phenomena around the world*. Pgs. 334-339 in *The eruption of Krakatoa and Subsequent Phenomena*. Trubner and Co., London.

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Biographical Sketch

Dr. Kevin Hamilton is Professor of Meteorology and Director of the International Pacific Research Center at the University of Hawaii. He received his doctoral degree in 1981 and has worked as a researcher, teacher and administrator at universities and laboratories in both the USA and Canada. His principal research interests have been in the fields of middle atmospheric dynamics, general circulation modeling of the global atmosphere, and climate diagnostics. He served two terms as the President of the International Commission for the Middle Atmosphere. He is the author or coauthor of over 100 refereed publications.