Geophysical Research Abstracts
Vol. 16, EGU2014-8257, 2014
EGU General Assembly 2014


# Mechanisms of the Holton-Tan relationship and its decadal variation

Hua Lu (1), Thomas Bracegirdle (1), Tony Phillips (1), Andrew Bushell (2), and Lesley Gray (3)

(1) British Antarctic Survey, Cambridge, United Kingdom (hlu@bas.ac.uk), (2) Met Office, FitzRoy Rd Exeter Devon EX1 3PB, United Kingdom (andrew.bushell@metoffice.gov.uk), (3) National Centre for Atmospheric Science, Reading, and University of Oxford, Oxford, United Kingdom (GrayL@physics.ox.ac.uk)

A relationship between the equatorial quasi-biennial oscillation (QBO) and the northern stratospheric winter polar vortex, often referred to as the Holton-Tan effect (HT effect), has been the subject of studies since the 1980s. It is a phenomenon in which the strength of stratospheric winter polar vortex is influenced by the equatorial quasi-biennial oscillation (QBO). More specifically, the vortex becomes stronger and colder when the QBO is in its westerly phase (wQBO) and weaker and warmer when the QBO is in its easterly phase (eQBO). Though the HT effect has been successfully reproduced general circulation models, the underlying mechanism is still not clearly identified.

It has been found that the HT effect is not stationary and it has been disrupted over the 1977-1997 period. The disruption of the HT effect in 1977-1997 started in December and intensified in late winter, during which period the sign of the HT effect even reversed. The weakening of the HT effect during 1977-1997 was associated with a seasonal shift of the timing of SSWs.

This study provides a mechanistic explanation of why the HT effect, was disrupted in the mid- to late winters of 1978-1997. In line with recent reassessments of the HT effect, we find that an easterly QBO in the lower stratosphere leads to the formation of a mid-latitude wave guide that enhances both the upward propagating planetary waves from the troposphere into the lower stratosphere (35-50N, 30-200hPa), and the northward wave propagation in the upper to middle stratosphere (35-60N, 20-5hPa). This enhanced poleward refraction of planetary waves results in a more disturbed polar vortex, causing the HT effect. The weakening of the HT effect in 1978-1997 was associated with a strengthened polar vortex in November to January. The strong vortex during this period enhanced equatorward planetary wave propagation at 50N, 20-5hPa as a result of waves being refracted away by the strong westerly winds. This effect interfered with the QBO modulation of planetary wave propagation in this region and led to a weakening of the HT effect during the period. The stronger than average polar vortex in 1978-1997 was associated with a vertically coherent cooling signature over northeastern Asia in the stratosphere. We suggest that a change of stratospheric circulation was the main cause for the disrupted HT effect in 1978-1997.